RETURN

(104)

To an Order of the House of Commons, dated the 17th of January 1912 for a copy of the Report of the Board of Engineers appointed for the reconstruction of the Quebec Bridge, and of the plans and specifications prepared by them; of all notices calling for tenders; of all tenders received; of the report of the Board on the same, collectively or individually, to the Minister of Railways; of the report of the said Minister for the acceptance of tenders, and any Orders in Council awarding contracts for the building of the said bridge.

W. J. ROCHE,
Secretary of State.

Ottawa, 2nd of February, 1912.

[Copy file No. 11331-485.]

Department of Railways and Canals.
BOARD OF ENGINEERS, QUEBEC BRIDGE.

Montreal, January 29, 1912.

Dear Sir,—In reply to your request of the 19th instant, I am sending you plans and specifications, in duplicate, which were prepared by the Board of Engineers, for the calling of tenders. I am also sending the following reports, in triplicate:

Unanimous resolution dated May 2, 1910, approving of the Board's plans for the calling of tenders;

Unanimous report dated October 26, 1910, signed by the three members of the Board;

Majority report dated November 3, 1910, signed by Messrs. Macdonald and Modjeski;

Minority reports dated December 10, 1910, and January 20, 1911, signed by Mr. Vautelet;

Report of increased Board dated February 8, 1911, signed by Messrs. Butler, Hodge, Modjeski and Macdonald;

Unanimous report of Board dated March 14, 1911, signed by Messrs. Macdonald, Modjeski and Hodge.

This, I think, covers all the information required by the Order, as outlined in your letter of the 19th instant.

Yours very truly,
(Signed) C. N. MONSERRAT,
Chairman and Chief Engineer.

L. K. Jones, Esq.,
Secretary, Dept. of Railways and Canals,
Ottawa, Ont.

BOARD OF ENGINEERS, QUEBEC BRIDGE.

COPY *of resolution passed at a meeting of the Board held May 2, 1910.*

It is resolved that the plans and specifications for a cantilever design now completed be approved and submitted to the Minister for tenders and that in the event of a better plan being submitted by any of the bidders same shall be adopted.

(Sgd.) RALPH MODJESKI.

(Sgd.) H. E. VAUTELET.

WITNESS: (Sgd.) A. W. CAMPBELL.

MONTREAL, 2nd May, 1910.

WEDNESDAY, October 26, 1910.

SIR,—Your Board met in Montreal on Monday, October 10, 1910, to consider the plans sent by different companies for the Quebec bridge superstructure, and also copies of the tenders which had been made by the secretary of the Board.

These copies were compared on the following day with the originals, which were brought to Montreal by an officer of your Department.

A detailed statement in tabular form is enclosed.

Since that date the Board has been in session practically continuously.

After a careful study of the tenders received on the Board's design and on alternative designs submitted, amounting in all to thirty five different propositions, your Board has eliminated, as not acceptable, all but the following:

1st. Design No. V of the Board, with short shore arms and floating erection of the suspended span on high staging, tenders on which were submitted by all four firms.

2nd. Design "A" of the St. Lawrence Bridge Company, being different in outline from the Board's design and having the top chords built of nickel steel plates throughout.

3rd. Design "B" of the St. Lawrence Bridge Company, similar in all respects to Design "A", except that the top chords of the anchor arm are built of carbon steel.

4th. Design "C" of the St. Lawrence Bridge Company, similar in all respects to "B", with the exception of the top chords, which are designed with eyebars, instead of plates.

Classified for cost only, they are as follows:

1.	British Empire Bridge Co. . .	Board Design V. . .	$11,025,566
2.	Pennsylvania Steel Co.	" " V. . .	11,686,751
3.	St. Lawrence Bridge Co. . . .	Design B.	11,957,500
4.	" "	" A.	12,153,500
5.	" "	" C.	12,216,400
6.	Maschinenfabrik Augs-Nurn. . .	Board's Design V . .	13,230,050
7.	St. Lawrence Bridge Co. . . .	" " V. . .	14,867,170

The cost as per specifications may be increased by 2 per cent and includes an amount of $118,500 to be paid to Messrs. M. P. and J. T. Davis for increased quantities of masonry in the anchor and short piers. The Pennsylvania Steel Company and the British Empire Bridge Company, according to their tenders, use a somewhat larger number of splices in the bottom chord than shown on the Board's plan. Your Board may later on recommend that their figures be slightly increased, in order to reduce the number of splices.

Your Board does not consider that it is within their province to report on the financial status and ability of the different contractors.

They beg, however, to submit the following notes:

British Empire Bridge Company, Limited.—This is a Company incorporated in Canada at a capital of $5,000,000. It was formed by the Cleveland Bridge & Engineering Co., Limited, of Darlington, England, and by the Patent Shaft and Axletree Company, of Wednesbury, England.

Our Chairman reported that he had visited the works of these companies. That the Cleveland Bridge & Engineering Company, at the time of his visit, was a modern bridge shop of about 12,000 to 16,000 tons annual capacity.

That the Patent Shaft and Axletree Company was one of the largest firms in England and that their bridge department was composed of two large main buildings. He could not judge of their equipment, as no bridge work was being done at the time of his visit.

The representative of the British Empire Bridge Company submitted photographs showing some of the bridges built by the parent companies, including a 500-foot arch over the Zambesi river at Victoria Falls, Africa.

He also stated that the Patent Shaft and Axletree Company had a capital of £1,500,000, with a reserve of £400,000 together with other reserves; that their stock was issued at £1 par value and was now selling at £3.

This company has no assets known to us except an accepted cheque for $500,000, which we assume to be in the hands of the Minister, and your Board does not know if the parent companies would become parties to the contract.

The British Empire Bridge Company state that they would establish works in this country, where all parts of the bridge, except the raw material, would be manufactured.

Pennsylvania Steel Company.—This firm is considered one of the strongest in the United States and has apparently very large assets.

Your Board has no doubt about their ability to build the bridge and fulfil all the conditions of the contract.

It is not quite clear how much, if any, of the shop work would be done in Canada. Transportation of large members from their present shops would be very risky.

Maschinenfabrik Augsburg-Nurnberg A.G.—Your Board does not know anything definite about this firm. It proposes to manufacture the bridge partly in Germany and partly in Canada, in connection with the Canada Foundry Company, Limited, of Toronto, in which case the same observation about transportation would apply to a much larger extent. They also state that they may decide later on to build everything in Canada.

St. Lawrence Bridge Company, Limited.—From information given by their representative, this is a company incorporated in Canada with a capital of $500,000, to be increased as need may be.

The Dominion Bridge Company and the Canadian Bridge Company each own one half the number of the shares, but neither parent company will become a party to the contract.

This company has no assets known to us except an accepted cheque for $500,000, which we assume to be in the hands of the Minister. The parent companies are very strong and very well known companies and there is no doubt about the ability of the men at their head to carry the contract to a successful issue.

Specifications.

The Maschinenfabrik Augsburg-Nurnberg A.G. does not ask any modifications of the specifications. They only state that no nickel steel material will be longer than 53 feet, which is acceptable to the Board.

The Pennsylvania Steel Company and British Empire Bridge Company discussed the specifications with the Board. A complete understanding, signed in each case by the representative of the company and the members of the Board, has been arrived at.

The St. Lawrence Bridge Company has asked for several modifications to the specifications. In the case of their tender on the Board's plans an agreement can probably be arrived at on the basis proposed, except on the question of eyebars. They propose to make further experiments on the manufacture of the eyebars, so as to come to an agreement with the Board

There have also been some modifications and additions to the specifications and contract form, asked for by all the bidders, such as customs duties, &c., for which your Board was not qualified to act and for which the contractors have been referred to you.

Your Board is of the opinion that it is possible to construct a bridge in accordance with either of the tenders received upon the Board's design No. V, which would make a satisfactory structure.

Your Board is also of the opinion that it is possible to construct a bridge in accordance with Designs 'A', 'B' and 'C' submitted by the St. Lawrence Bridge Company, which would make a satisfactory structure, providing that plans, details and material were made in accordance with the specifications of the Board, including modifications allowed to other bidders.

Respectfully submitted,

(Sgd.) CHARLES MACDONALD,
" RALPH MODJESKI.
" H. E. VAUTELET.

Hon. GEO. P. GRAHAM,
Minister of Railways and Canals,
Ottawa, Canada.

Copy.

QUEBEC, November 3, 1910.

DEAR SIR,—In reply to your request of the 1st November asking for a definite recommendation for the acceptance of tenders respecting the Quebec Bridge, probably it would be well to give a little history of the situation. The public possibly do not realize the immensity of the undertaking and only members of the engineering profession can fully comprehend it. Nothing of equal magnitude has ever been attempted. Every engineer in connection with it has felt an indescribable responsibility. Under the circumstances, it is not to be wondered at, but rather is a proof of the care they have exercised that differences of opinion should have arisen as to the best method of accomplishing this task.

When the members of the Board as originally constituted first considered this great project they knew it was the greatest work ever undertaken and they endeavoured to approach it with open minds. After very careful study they discovered that their views did not coincide on some points. Part of the Board were inclined to favour the double intersection principle, similar to that adopted in the famous Forth Bridge, while the other portion felt equally convinced that double inter-

section was not practical for such a structure. Studies were made along both lines, but neither party was convinced that their ideas were not the best. There being a divergence of view on this point, it was decided to advertise for tenders on the official plan prepared by the Chairman and Chief Engineer on the single intersection principle with the mutual understanding that while tenders were asked on this design, tenderers were to be allowed to present any other design they chose, which would be fully considered by the Board on an equality with the official design.

This decision was embodied in a unanimous resolution of the Board passed on May 2, 1910;—

> 'It is resolved that the plans and specifications for a cantilever design now completed be approved and submitted to the Minister for tenders and that in the event of a better plan being submitted by any of the bidders same shall be adopted.'

The advertisement for tenders consequently contained a clause embodying the principle of this resolution.

A full history of the tenders received appears in our former report. It will be seen that ten tenders were received for designs other than the official design, according to the advertisement, and they were considered, as outlined in a former report.

On close investigation of the alternative designs it was found that one, presented by the St. Lawrence Bridge Company, while designed on the single intersection principle, in a very practical way met all the demands that a portion of the Board had in their minds when they favoured the double intersection principle. It certainly is an original and happy combination, which embodies to a large extent the views of the advocate of each of the principles—single and double.

As stated in our former report, a bridge could undoubtedly be constructed on the official design, and once erected would be a substantial structure, but we are of opinion that design 'B,' in addition to providing for a satisfactory bridge offers features which simplify the erection and minimize, the risk to both life and property entailed in a work of such magnitude. This we consider of paramount importance. In addition to this we favour design 'B' for the following reasons:

1. The numerous temporary members, sub-trusses and other connections to the permanent members involved in the official design are all dispensed with in design 'B'.

2. The erection can proceed in a regular manner, the traveller being carried on the main members only and as it advances each operation is similar to the preceding one, which similarity greatly favours speed and safety in construction.

3. There are no members in the trusses that do not carry live load with the exception of two small struts over the centre pier.

4. There is less distortion and secondary stress as may be seen by comparing the Williot's Diagrams, showing in each case the deflections of the trusses for different conditions of loading.

5. The 'B' design admits of comparatively small stresses in the web members, thus rendering connections with the chords much more simple.

6. No pin holes are required in the chords as connections are made by means of gussets, thus evading loss of section by large pin holes and permitting the compression members to abut with half holes in gusset plates outside the chords. The absence of pin holes in the centre line of the chord permits the use of a centre diaphragm connecting the several leaves of the bottom chord and presenting a more symmetrical section than in the official plan.

7. By the substitution of riveted tension chords for eye-bars all risk and difficulty of assembling a double line of eyebars with the heavy inclined posts in the official plan is removed and the diagonal tension and compression web members are in practically the same vertical plane as the corresponding leaf of the upper chord, thus insuring a more direct transmission of stress.

8. All the heavy extras demanded by steel makers occur in the long and heavy web members of the official design. Owing to smaller stresses in the 'B' design these extras may be avoided, thus insuring less risk in the use of material which is beyond commercial limits.

9. The general appearance of design 'B' will certainly be appreciated from an æsthetic point of view, the large open panels and wide riveted members convey the idea of strength combined with economical distribution of material, which is the true test of scientific construction. A bridge constructed upon this design would compare most favourably with the highest type of long span bridges in existence.

We, therefore, beg to recommend the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B'. We do not wish to be understood as condemning any other design nor is this recommendation in any sense a reflection on any of the companies tendering, but we have arrived at this conclusion after a careful study of all the designs and conditions.

Respectfully submitted,

(Sgd.) CHARLES MACDONALD.

" RALPH MODJESKI.

Hon. GEO. P. GRAHAM,
Minister of Railways and Canals,
Ottawa, Ont.

MONTREAL, December 10, 1910.

SIR,—In reply to your letter of November 29, 1910, enclosing communication of my colleagues addressed to you and dated November 3, 1910, I beg to submit the following remarks:

The Board derives its powers from the following Order in Council, dated August 17, 1908, in which it is said:—

'They shall prepare a new design, together with a specification, working drawings, estimate of cost and all such things in that connection necessary as preliminary to proceeding with the work, and submit the same *to the Department of Railways and Canals for its actions thereon.*'

Owing to different views held by the members of the Board an agreement was arrived at in November and December 1909 that tenders would be received on the Board's plans and also on plans made by contractors, according to the specifications of the Board.

In accordance with said agreement an advertisement dated Ottawa, 24th November, 1909, was put in the papers by the Department, stating that:

'The contractor is invited to submit alternative designs *which must conform to the conditions laid down in the general specification.*'

Preliminary specifications were issued, dated January 1, 1910, in which we find

'Paragraph 6.—TENDERS. Tenders will be received on plans prepared by the Board, but contractors are invited to submit plans of their own, *made according to this and later specifications.*'

Complete specifications were also issued dated June 1, 1910, in which we find

Paragraph 4.—Contractors will be allowed to submit tenders on plans of their own or on modifications of the Board's plans, *but all tenders shall be subject to these specifications.'*

Finally an advertisement dated June 17, 1910, was put in the papers by the Department which states that:

(*a*) 'tenders will not be considered, unless made strictly in accordance with the printed forms.'

The printed forms (contractor's plans) state that the plans must be *in accordance with the specifications exhibited* and a foot note states that the specifications referred to above are those entitled 'Specifications for Superstructure' dated Montreal, June 1, 1910.

(*b*) That the deposit will be forfeited

'if the party tendering declines entering into contract for the work at the rates stated in the offer submitted and in accordance *with the terms stated in the form of contract accompanying the specifications.'*

In connection with the above, see form of contract, page 47:

'which said specifications and supplementary specifications, plans and drawings are hereby declared to be part of this contract.'

On October 26, 1910, a report was sent you signed by all the members of the Board, in which you were advised:

(*a*) that four tenders on plan No. V of the Board were acceptable.

(*b*) that tenders on plans 'A', 'B' and 'C' of the St. Lawrence Bridge Company would be acceptable 'providing that plans, details and materials were made in accordance with the specifications of the Board, including modifications allowed to other bidders.'

The last paragraph means evidently that the plans, details and materials were not, at that date, made in accordance with the specifications of the Board and did not come within the requirements of the Department as advertised by public notice.

The only tenders, therefore, acceptable to the whole Board and conforming to the requirements of the Board and Department, were the four tenders on plan No. V of the Board.

On November 1st you wrote me asking that the Board recommend which of the tenders mentioned in the report should be accepted.

At a meeting of the Board held November 2nd I submitted your letter to my colleagues. At this meeting the St. Lawrence Bridge Company's officials were present and submitted a special specification for compression members, which was entirely different from the specifications of the Board and which, if accepted, as will be shown later on, would result in the construction of a bridge much weaker than proposed by the Board. Later in the day my colleagues advised me that they had made up their minds to recommend the acceptance of the tender of the St. Lawrence Bridge Company on its own design and that, consequently, they would either send a majority report to the Minister, or ask that two engineers be added to the Board as provided for by the Order in Council. I suggested that the first course proposed by them be followed.

This recommendation was forwarded to you by my colleagues in a letter dated November 3, 1910.

On November 12th I answered your letter of November 1st informing you that I had nothing to add to the unanimous report of October 26th, 1910. My reason for doing so was that I have never understood, from the time I joined the Board, that the clause of the Order in Council quoted above, allows us to recom-

mend the acceptance of any particular tender. I have always understood that this clause in the Order in Council leaves the choice of the tender to be accepted, to the Department, and that the duties of the Board are only those of a technical adviser.

Conditions, other than technical, may affect the choice, such as financial status, honest performance of previous contracts, public interest, &c., which the Board is not qualified to judge of, and on which it cannot get information as readily as the Department. My understanding of said clause was confirmed by the fact that the tenders for the masonry were not submitted to the Board, nor was it asked to recommend to whom the contract should be given.

Referring to the first part of the recommendations of the Board in their report of October 26, 1910, I beg to submit the following remarks, in regard to design V of the Board:

(*a*) This plan has been accepted by all my colleagues. (Reports Nos. 11 and 15, and report of October 26, 1910.)

(*b*) Four of the best bridge companies of England, Canada, the United States and Germany have tendered on the Board's design, and, in accordance with Paragraph 8 of the preliminary specifications and Paragraph 5 of the final specifications, are ready to absolutely guarantee, with a deposit of one and a half million dollars, the satisfactory erection and completion, as well as the materials, construction, design, calculations, plans, specifications and sufficiency of a bridge built in accordance with this design.

(*c*) Amongst the tenders submitted on the Board's design No. V, one tender is $950,000 and another tender is $270,000 cheaper than design 'B' of the St. Lawrence Bridge Company, and the two tenders are respectively $1,200,000 and $250,000 cheaper than design 'C'.

(*d*) The English, American and German firms guarantee the completion of the bridge on design No. V of the Board, one year earlier than the St. Lawrence Bridge Company on their own designs 'A', 'B' and 'C'.

(*e*) The plan of erection I proposed for the suspended span has been adopted by all the contractors and will eventually save one year in the completion of the bridge.

(*f*) The tenders received on the Board's design and approved by the Board are as follows:—

British Empire Bridge Company..	$11,025,566 20
Pennsylvania Steel Company..	11,686,751 30
Maschinenfabrik Augsburg-Nurnberg..	13,230,050 10
St. Lawrence Bridge Company..	14,867,170 00

The first three tenders are well within the estimated cost sent to the Department on June 3, 1910, and which, for reasons given, ranged between $11,230,213 and $13,409,983.

(*g*) Plans and calculations of the Board's design are very complete and fulfill all the requirements of the Order in Council creating the Board. The estimated cost sent you on June 3, 1910, has proved correct.

(*h*) The design of compression members and connections has been thoroughly tested and the tests have given the most satisfactory results, as shown in the report sent you on August 1, 1910.

(*i*) Board's plan No. V complies with all the requirements of the Board and Department. From an engineering standpoint any of the four tenders on this plan could, therefore, be accepted by the Department, having been unanimously approved in the Board's report of October 26, 1910.

(*j*) Design No. V of the Board is stronger than designs 'A', 'B' and 'C' of the St. Lawrence Bridge Company, as will be shown later on.

Coming now to the letter of my colleagues dated November 3, 1910, I enclose a copy (Appendix 'A') having the paragraphs numbered for reference.

Paragraph 1.—I heartily agree with this part of the letter. The difficulties noted therein, and my desire to put all the facts before you are my only excuse for writing such a long letter.

Paragraph 2.—I beg to submit a few remarks on the question of single or double intersection, as follows:

During the early stages of the work a majority of the Board, composed of my two colleagues, favoured double intersection; a minority, composed of the Chairman, favoured single intersection.

I did not rely on my knowledge alone, but consulted on this point many well known engineers.

Amongst others the following, for one reason or another, favoured single against double intersection:

Mr. C. G. Emil Larsson, of the American Bridge Company.
Mr. Fred. W. Cohen, of the Pennsylvania Steel Company;
Mr. Phelps Johnson, of the Dominion Bridge Company;
Mr. John Sterling Deans, of the Phoenix Bridge Company.

The former Deputy Minister was present at some of the meetings where the question was discussed. Letters written on that subject by some of these engineers were sent you June 17, 1909, and April 25, 1910.

After two members had been added to the Board, my two colleagues and Mr. Paul L. Wolfel, of the McClintic-Marshall Construction Company favoured double intersection; Mr. Phelps Johnson and myself favoured single intersection.

After tenders had been called, allowing contractors to present their own designs, three designs for cantilevers were submitted by the contractors; one by the Germans which is single intersection, and two by the St. Lawrence Bridge Company which are also single intersection.

No design for a double intersection bridge was presented by any firm. I felt, therefore, that my convictions on this point have been fully justified.

Paragraph 3.—As shown by the advertisements for tenders and by the preliminary and final specifications, to this paragraph should have been added the words:

'Provided that plans, details and material be made in accordance with the specifications of the Board.'

This, of course, would have stopped any further argument, but without them the sentence referred to is incomplete and does not give all the facts.

Paragraphs 4 and 5.—The same remarks on paragraphs 2 and 3 apply to paragraphs 4 and 5.

Further, the system of main panelling adopted in designs 'A', 'B' and 'C' is not original, as it was published for the first time, to my knowledge, in 1901 by a Russian engineer for a 135 feet span. I am not aware that any bridge, large or small, has been built on that system since that date. This must not be understood as condemning the system.

Paragraph 6.—Out of three similar designs, 'A', 'B' and 'C', submitted by the St. Lawrence Bridge Company, design 'B', which complies least with the specifications of the Board, is recommended by my colleagues. I cannot see any reason for their choice except that it is the cheapest of the three.

My colleagues also state that this design offers features which simplify the erection and minimize the risk to both life and property.

This, of course, is an expression of opinion sustained by neither reasons nor facts. I can only submit the reasons which helped me to form a different opinion and which are as follows:

(*a*) The letters received from the engineers I had consulted and which are referred to above.

(*b*) The opinion of Mr. Phelps Johnson, as shown in page two of report No. 11 of the Board, and in the minutes of the meeting held September 7, 1909:

'He saw no unusual difficulties in the erection of this design (Board's design)."

(*c*) The schemes of erection proposed by the St. Lawrence Bridge Company are identical, both for the Board's design and for their own design. I am, therefore, unable to understand why more men or property would be injured in the one case than in the other.

Blue prints (Appendix 'B') showing the different modes of erection proposed by all contractors and copy of a letter from the St. Lawrence Bridge Company dated October 15, 1910 (Appendix 'C') explaining the different schemes of erection, are attached to this letter. (Note passages underlined by myself).

I would say, however, that I differ from the opinion *re* top travellers, expressed in that letter and believe they are at least not more dangerous than through travellers for the following reasons:

(*a*) Clauses 17 and 19 of the contract put the complete responsibility for damages to persons or property, solely on the contractor. It is, therefore, to be presumed that all contractors have given this question their best consideration, from a business if not from a humanitarian point of view.

With this in view top travellers are adopted by the Germans in their own design, the British Empire Bridge Company and the Pennsylvania Steel Company, although the latter had lately used through travellers for the erection of an 1,182 ft. cantilever span in connection with the Blackwell's Island Bridge at New York. Their choice of top travellers for the Quebec Bridge must, therefore, be the result of their experience in the erection of large cantilever bridges. Their engineer of erection is reputed to be one of the best in America.

(*b*) The latest large cantilever bridge, erected in America, at Beaver, Pa., was erected with top travellers and the engineer in charge told me their use had been very successful.

(*c*) Top travellers rest on the members of the trusses themselves, instead of on the bridge floor. As they are much smaller than the through travellers, offering less surface to the wind, and have a much wider base, they have consequently greater stability and the risks attending life and property are correspondingly less.

(*d*) Top travellers, which never are higher than through travellers, follow the top chord and come gradually lower as erection progresses and becomes more dangerous, whereas through travellers remain always at the same height and when they come near the end of the cantilever arm, offer a large surface to the wind and are apparently more dangerous for the men.

I think, however, in view of the guarantees exacted from the contractors by the terms of the contract, that the choice of the scheme of erection and the erection appliances should be left to the contractor, subject to the supervision of the Board.

Paragraph 7.—Temporary members will, of course, be numerous in any design for such a large structure. Three temporary heavy members in each truss or twelve altogether are required for the Board's design.

They are similar to other members used heretofore for the erection of the suspended span of cantilever bridges.

All such temporary members are part of the falsework and their cost is included in the tenders.

Paragraph 8.—The schemes of erection proposed by the St. Lawrence Bridge Company are identical, whether for their own design or for the Board's design. If through travellers are used they are carried on the main members in either case. As all the panels of the Board's design are similar, the operations are also similar. But as stated in paragraph 3, I am in favour of top travellers and cannot see, in a structure of this size, what difference it would make if the operations for each connection are different.

Paragraph 9.—I fail to see the importance of this remark.

(*a*) because there are numerous members in the suspended span of design 'A', 'B' and 'C' which do not carry live load. Why are they harmless in the suspended span and harmful in the cantilevers?

(*b*) There is a large number of members in both designs, namely, the materials and sway bracing which do not carry live load, and they have the same effect in preventing the free deformation of the trusses under live load.

(*c*) All trusses of large bridges, such as the Thebes Bridge and the projected cantilever bridge over the Hudson River have a large number of members which do not carry live load and I am unaware of any criticism having been levelled at them by any one on that account.

(*d*) Design 'C' of the St. Lawrence Bridge Company, which is the only one amongst 'A', 'B' and 'C' that comes within clause 74 of the specifications, has a large number of such members.

Designs 'M' and 'N' of the same company and guaranteed by them, contain such members, in excess of the number used in the Board's design.

The design of the Germans has also a large number of such members.

None of the contractors have ever protested against such members in the Board's design, the construction, erection and efficiency of which design all of them are ready to guarantee.

Paragraph 10.—The Williot's diagram of design 'B' are for a 502 ft. anchor arm built of carbon steel, and no comparison can be made with the Williot's diagrams for the 586 ft. anchor arm of the Board's design built of nickel steel, and as Williot's diagrams of the cantilever arm of design 'B', which would have given a true measure for comparison, and should have been furnished as per paragraph 108 of the specifications, have not been submitted by the St. Lawrence Bridge Company, no comparison at all can be made.

The diagrams produced do not, therefore, show that there is less distortion in each case.

This whole matter has really very little importance as deformation is not a measure of strength; for if we compare two members of same length, but of different depths, the same amount of bending deformation which would be harmless in the shallower member may cause the failure of the deeper one.

It is, however, necessary to determine the deformations and the strains they cause. This has been done, with the greatest care, in connection with the Board's design, as may be seen by referring to the drawings exhibited, and in all cases the strains resulting from the deformations have been amply provided for.

Paragraph 11.—As the web members, as well as the bottom chords of the Board's design, are erected in half widths they are just as easy to handle and to connect, if not easier, than the web members of design 'B.'

Paragraph 12.—The opinion hereby given is contrary to the universal practice of bridge engineers in America. Very few instances could be shown where this has been done. This kind of connection has been limited in the Board's design to as few members as erection would allow, especially for compression members,

where its use was deemed inadvisable. An instance of it is shown at the end of the cantilever arm, where special precautions have been taken to avoid the objectionable features of such a connection. I have, however, always intended to change this detail, if possible, in the final drawings. The excellency of the connections used in the Board's design has been shown conclusively by tests T4A and T4B, and T6A and T6B, made at Phœnixville. The connections proposed by the St. Lawrence Bridge Company have not been tested.

Paragraph 13.—This statement is irrelevant unless it means that the chords proposed by the St. Lawrence Bridge Company are better than the chords of the Board. It is a bold statement in the absence of actual tests of the St. Lawrence Bridge Company's chords and in the face of the extremely satisfactory results obtained in the tests made at Phœnixville on models of the Board's chords T1A and T1B, and T2A and T2B, and of a sentence in letter No. 1 accompanying the tenders of the St. Lawrence Bridge Company, where we read:

'The results obtained in the tests of nickel steel columns made by the Board were, in some cases, unusually and unexpectedly high *and it is doubtful that so high values can again be reached unless the Board's experiments are exactly duplicated.*'

I would also remark that longitudinal splicing, as shown in the St. Lawrence Bridge Company's design, has been tested by the Board and have given very inferior results as shown by tests T7A and T7B.

The results of all the tests referred to were sent to you on August 1, 1910.

Paragraph 14.—The first part of the sentence is in direct contradiction with clause 74 of the specifications. It is also in direct contradiction with the often expressed opinion of one of my colleagues that eyebars are the most reliable form of tension members. One might well hesitate, before accepting field riveted connections of tension members over five inches thick, not including splice plates.

A double line of eyebars is very much easier to assemble and less risky than a single line. The St. Lawrence Bridge Company propose themselves to use two lines of eyebars in design 'M' and 'N.'

Paragraph 15.—What does it matter if pins are carefully calculated according to American practice?

Paragraph 16.—Any extras demanded by steel makers are included in the prices named in the tenders and there is no risk, since all materials will be inspected and must come up to the specifications. Any material, which it is impossible to get on account of length, may be spliced and I would remark that splicing has been resorted to by the St. Lawrence Bridge Company to much larger extent than contemplated by the Board.

Paragraph 17.—This is certainly an unexpected argument, but I have no right to criticize the esthetic judgment of my colleagues.

Paragraph 18.—In view of all the preceding observations contained in this letter I cannot join in the recommendation of my colleagues,

(*a*) because it is contrary to the recommendation of the whole Board,

(*b*) because the tender referred to on design 'B' is not according to the requirements of the Board and the department, since it contains the words:

'This tender is based upon the specifications and draft contract as modified by our accompanying letter No. 1, of this date.'

According to the advertisement issued by the department on June 17, 1910, this tender should not be considered.

(*c*) because in letter No. 1 referred to above, we read, amongst many requests for changes in the specifications:

'The results obtained in the tests on nickel steel columns made by the Board were, in some cases, unusually and unexpectedly high *and it is doubtful that so*

high values can again be reached unless the Board's experiments are exactly duplicated.'

This is certainly a high compliment for the Board's design, but I do not see why anything not quite so good should be accepted.

(*d*) because amongst other clauses, design 'B' does not comply with vital clauses 68, 74 and 278 of the specifications.

The tender on any such design, if built according to the specifications of the Board, would be the tender on design 'C' at an extra cost of $250,000 or $1,200,000 above the lowest tender.

(*e*) Even if such tender were based upon the specifications of the Board, there are no plans before the Board to show how this would be done. Plan 'C' shows only two preliminary strain sheets. Neither the connections of eyebars in the top chords or web members, their layout, nor any other information are given. The bottom chords of plan 'A' which might be used for plans 'C' or 'B' are not acceptable in view of the results of tests T7A and T7B. A note on one of the plans says that if tests are not satisfactory they would be replaced by something else.

The word *satisfactory* in this case has no meaning since no guarantee of tests was given beyond the vague sentence in letter No. 1, accompanying the tenders:

'The specifications should, of course, require only such values as can reasonably be expected from carbon steel in the light of compression tests already made upon it.'

Such results would give a bridge much inferior in strength to the Board's design.

The Board could not, therefore, give an opinion on plans which do not exist.

Referring to the comparative strength of the Board's plan and of 'A', 'B' and 'C' designs, I enclose calculations showing the superiority of the Board's design (Appendix 'D').

The calculations for elastic limit are to a certain extent based on assumptions, and, besides, elastic limit and yield point cannot be absolutely compared. I have made the comparison as conservatively as I could, owing to the lack of knowledge on the limit of elasticity of built compression members, in regard to which no investigation has ever been attempted, at least to my knowledge, previous to the experiments made by the Board at Phoenixville.

The calculations for ultimate strength are correct and based on the minimum results obtained or specified by the Board and on the minimum results guaranteed by the St. Lawrence Bridge Company.

Of course, in a work of this magnitude, where such guarantees are asked from the Contractors and where a comparatively new kind of metal is used, I understand, that the specifications of the Board may have to be altered on such points that could not be ascertained before calling for tenders, such as extreme length of materials procurable, and the physical and chemical tests of materials that mills are ready to manufacture irrespective of cost. I was astonished to find out how little change was really insisted upon by the Contractors and steel makers and, of course, such changes, as agreed to by the Board, ought to be allowed to all Contractors alike. The case is different when the conditions of the contract have not been fulfilled, when vital clauses are concerned and where the changes asked for are absolutely contrary to the requirements of the Board and Department or diminish the strength of the bridge.

To conclude. As implicitly stated in the report of October 26, 1910, the plans, details and materials of designs 'A', 'B' and 'C' of the St. Lawrence Bridge Company are not made according to specification. They provide for a bridge weaker than the Board's design, as shown in Appendix 'D'.

Even if they could be made as strong as required by the specifications, there is no plan before the Board to show how this result would be attained.

The tenders of the St. Lawrence Bridge Company on their own designs 'A', 'B' and 'C' do not, therefore, comply with the requirements of the Board, as expressed in the specifications, nor of the Department, as expressed in the public notices and form of contract issued.

They cannot, therefore, be considered by the Board.

The Board's design, for the many reasons given on pages 4, 5 and 6, complies with all the requirements of the Board and the Department. It is satisfactory to all engineers and contractors concerned, and I do not know of any technical reason why either of the four tenders on this design should not be accepted.

Yours respectfully,

(Sgd.) H. E. VAUTELET,
Chairman and Chief Engineer.

Hon. GEO. P. GRAHAM,
Minister of Railways and Canals,
Ottawa, Ont.

MONTREAL, January 20, 1911.

SIR,—I beg to supplement my letter addressed to you on December 10th, 1910 by adding to page 6, the following remarks in regard to design V of the Board:

(*k*) A report of Sir Douglas Fox on the Board's design was transmitted to me by a representative of the British Empire Bridge Company, and reads as follows:

'Have made careful examination of Board's specifications, general designs and details. Specification is clear and concise and prepared with great care and judgment. It will ensure structure built combining stability and permanence with reasonable economy. Design admirably suited for its purpose. It is perfectly sound alike as to construction and erection and in detail is worked out with skill and judgment. Experiments on large models of compression members have enabled the design of vital parts to be prepared with certainty. Think no hesitation in proceeding with works on lines laid down.'

(1) Letter No. Two, dated September 30, 1910, attached to the tenders of the St. Lawrence Bridge Company stated:

'Had it not been for the many difficulties that came up on considering the erection of the Board's design we would have been content to have tendered on this design only, *believing the bridge in other respects to be all that can be desired.*'

As mentioned in my letter of December 10 (page 9), the difficulties of erection had become much less serious by October 15, 1910, when the St. Lawrence Bridge Company wrote:

'In a general way we may say that *for each design we have worked up in detail a scheme which we are satisfied will do the work safely* and on this we have based our estimates.'

and later, speaking of the Board's design:

'*With the inside traveller the risks above mentioned can, we think, be practically eliminated.*'

It follows, therefore, that in the opinion of the St. Lawrence Bridge Company the risks of erection have been practically eliminated and that the design of the Board is all that can be desired.

(*m*) On May 2, 1910, the following resolution was adopted at a meeting of the Board held in Montreal:

'It is resolved that the plans and specifications for a cantilever design now completed by approved and submitted to the Minister for tenders and that in the event of a better plan being submitted by any of the bidders same shall be adopted.'

I will remark first that this resolution allowed other plans to be submitted, *but not other specifications.*

When tenders were asked on the Board's design, that design had no defects, as far as the knowledge of the members of the Board went, because if any member had known of any defect it was his duty to have it corrected before advising the Minister to ask for tenders on such plans, as in the event of no other plan being submitted, the contract would have been given on the Board's design.

The choice, therefore, remains between a plan *that has no defects and is all that can be desired* and the designs of the St. Lawrence Bridge Company.

The only real argument brought in favour of the latter is that

'It offers features which simplify the erection and minimize the risks tc both life and property.'

This has been answered, pages 8, 9 and 10 of my letter of December 10, 1910.

If this is true it should have resulted in a lower cost of the bridge.

What are the facts:

The weight of both designs is practically the same. The materials used in the St. Lawrence Bridge Company's design cost over one million dollars less than the materials used in the Board's design. If the erection is simplified and the risks minimized the cost should be still less. Why, therefore, is the cost of the St. Lawrence Bridge Company's design $932,000 more than the lowest tender and $270,000 more than the next lowest tender on the Board's design?

The difference between the tenders of the St. Lawrence Bridge Company on plan V of the Board and on their plan 'B' is 19 per cent.

On the same basis it is, therefore, to be inferred that, had the other Bridge Companies been allowed to alter the specifications to the same extent as was done by the St. Lawrence Bridge Company their bids on the bridge would have been lessened in the same proportion, i.e., to $9,000,000 or to $9,500,000, instead of $12,000,000.

(*n*) The Board's design has been completely worked out and the compression members tested with highly satisfactory results, whereas the sketches submitted by the St. Lawrence Bridge Company are only in the initial stage. Their compression members have not been tested; tests will be required to ascertain their value, and repeated changes in designs and new tests may be required before as good members as the Board's may be obtained. (See Letter No. one of the St. Lawrence Bridge Company, quoted page 14 and 15 of my letter of December 10).

It will, therefore, take a much longer time to make the shop drawings for the design of the St. Lawrence Bridge Company than for the Board's design.

On December 13, 1910, I received a letter from the St. Lawrence Bridge Company enclosing copy of a letter addressed to you dated November 28, 1910, in which they agree to make their plans, details and material conform with the specifications of the Board. They do not state, however, what the cost will be. It is, however, another proof that the plans submitted with their tenders were not made according to the requirements of the Board and of the Department (See '*e*' page 16 of my letter of December 10, 1910). I would add that if the specifications are to be followed, the use of a through traveller will bring in the erection serious difficulties that presented themselves in all plans and which were avoided by the use of a top traveller.

In any case I feel very much gratified that as a consequence of our discussions the St. Lawrence Bridge Company has accepted the specifications of the

Board and that as a result a much stronger bridge has been secured for the country than the one which was originally proposed in their tenders.

Respectfully submitted,

(Sgd.) H. E. VAUTELET,
Chairman and Chief Engineer.

Hon. GEO P. GRAHAM,

Minister of Railways and Canals,
Ottawa, Ont.

MONTREAL, February 8, 1911.

SIR,—In accordance with your letter of January 20th appointing Messrs. M. J. Butler and Henry W. Hodge to advise with the Board of Engineers, Quebec Bridge, on the points of difference that have arisen in that Board, we have the honour to report as follows:

The Board, with the exception of Mr. Vautelet, who is detained in his home by illness, met with the advisory engineers on February 6, and have been in session for the past three days, Mr. Macdonald acting as temporary Chairman.

We have examined the various tenders and general designs and the advisory engineers have read the written opinions of the members of the Board, and in addition thereto, the opinion of Mr. Vautelet, as expressed in his letter to them dated February 2. They have also considered the verbal arguments of each member of the Board, adjourning to Mr. Vautelet's residence for the purpose of conferring with him.

The only point of difference in the Board is as to which specific design and tender should be recommended for acceptance; the Board being divided between the official design and the design of the St. Lawrence Bridge Company.

None of the tenders on either of these two designs were made without requiring modifications of the specifications, so that such alterations must be considered if either of these tenders are to be accepted.

The advisory engineers have not considered it within the province of their appointment to examine closely into the details of the two above mentioned designs and all of us are of the opinion that consideration of details is a matter that must be carefully studied and worked out in the light of further tests yet to be made by the Board of Engineers.

From our examination of the two above mentioned general designs, we, the undersigned, agree that the design of the St. Lawrence Bridge Company is preferable for the following reasons:

(*a*) The type of design offers greater safety to life and property during erection, as well as economy and rapidity in construction.

(*b*) The design contains the minimum number of secondary members and requires few, if any, temporary members during erection.

(*c*) The system of triangulation by dividing the web stresses reduces the members to more practical sections and simplifies the details of connections.

(*d*) The design economizes material as shown by the calculated weights of the two designs.

(*e*) The general appearance of the structure is, in our opinion, improved.

We feel that in a work of such magnitude the question of design is of the first importance and for the reasons given above we recommend the acceptance of design 'B' of the St. Lawrence Bridge Company, subject to certain modifications in general outline and detail, which we deem advisable and which will result in economy, and further improvement in appearance. The modifications

of their design we have in mind will reduce the cost of the work by, at least, four dollars per ton and we recommend the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B' at a price not exceeding 8.45 cents per pound (amounting in the calculated weight to $11,246,100) and at a corresponding reduction on their other pound price, if the Board should decide to accept any features of their alternate tenders.

The lowest tender of the British Empire Bridge Company, when the additional price they give for complying with the splices required by the official design is added, amounts to $11,320,720.

While not called for by the advertisement, the St. Lawrence Bridge Company submitted among their tenders, one omitting the roadways, which at the reduction in their pound price above recommended, shows a cost of $8,650,000 on the figured weight and we think this should be called to your attention, as the highways can now be omitted without changing our above recommendations or delaying the progress of this work.

We have the honour to be, Sir,

Your obedient servants,

(Sgd.) M. J. BUTLER,
HENRY W. HODGE,
RALPH MODJESKI,
CHARLES MACDONALD,
Chairman pro tem.

Hon. GEO. P. GRAHAM, L.L.D., P.C.,
Minister of Railways and Canals,
Ottawa, Ont.

MARCH, 14, 1911.

SIR,—Under date of February 8th, your enlarged Board of Engineers recommended the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B' subject to modifications which would, in their opinion, improve the structure and reduce the cost.

In this same Report we called your attention to a design of the St. Lawrence Bridge Company omitting the highways, by the adoption of which about $2,600,000 could be saved. This design is marked 'X' and is in every way similar to design 'B' except that it omits the highways, but retains two four-foot sidewalks.

We have now been informed by you that the St. Lawrence Bridge Company agree, in view of the modifications mentioned above, to reduce their price on either design by $4 per ton.

We are also informed by you that the Government has decided to omit the highways.

We hand you herewith a diagram (marked Drawing No. 1) showing the design as modified, and we also hand you a memorandum explaining the omissions and revisions required in the specifications, together with a copy of the original printed form with the necessary erasures and additions.

We recommend the signing of a contract for the superstructure of the Quebec Bridge with the St. Lawrence Bridge Company on their design 'X' as modified by attached sketch and under the revised specifications herewith submitted at a

price of (9.02) nine and two-one hundredths cents per pound, which as given in our report of February 8, will approximately amount to $8,650,000.

We have the honour to be, Sir,

Your obedient servants,

(Sgd.) CHARLES MACDONALD,
RALPH MODJESKI,
HENRY W. HODGE.

Hon. Geo. P. Graham,
Minister of Railways and Canals,
Ottawa.

BOARD OF ENGINEERS, QUEBEC BRIDGE.

PRELIMINARY SPECIFICATION FOR SUPERSTRUCTURE.

1. This preliminary specification is issued to supplement ordinary standard specifications for bridge work, to allow Contractors to become thoroughly acquainted with the requirements of the Board of Engineers appointed for the reconstruction of the Quebec Bridge and to allow such Contractors to be prepared to submit tenders which will form the base of a contract to be entered into by the Hon. the Minister of Railways and Canals, at Ottawa, Ont., hereinafter caller 'the Minister,' and a party or parties hereinafter called 'the Contractor,' to build, furnish and erect the superstructure of the Quebec bridge.

2. *Complete specifications.*—Complete specifications will be issued later on, and in the meantime all information at hand can be had at the Chief Engineer's office at Montreal, after January 3, 1910.

3. *Main piers.*—The superstructure of the new bridge shall be erected on two main piers as per plans attached.

4. *Length of Span.*—The main span shall be 1,758 ft. long, centre to centre of piers, with trusses 88 ft. centre to centre, and a maximum depth of 290 ft.

A clear head room must extend for 600 ft. at the centre of the main span and no part of the steel-work for that length shall be below Elev. 251.30 under maximum load, leaving 150 ft. clear height above highest water.

The plan of crossing attached shows the position of the two main piers and of the two existing abutments with elevations. The grade on the bridge must not be more than one per cent, the 600 ft. at the centre of the main span being level, except for the camber (see paragraph 15).

5. *Date of tendering.*—The date on which tenders will be received will be fixed later, but will not be earlier than May 1, 1910.

6. *Tenders.*—Tenders will be received on plans prepared by the Board, but Contractors are invited to submit plans of their own, made according to this and later specifications.

7. *Plans of the Board.*—Tenders will be received at a price per pound on the plans made by the Board for the bridge built and erected complete and ready for traffic, as per specifications to be issued later (paragraph 2).

8. *Conditions of Contract.*—I. The Contractor must satisfy himself as to sufficiency and suitability of the design, plans and specifications submitted by the Minister, as he (the Contractor) will be required to guarantee the satisfactory erection of the bridge according to such design, plans and specifications, and it is to be expressly understood that he undertakes the responsibility not only for the materials and construction of the bridge, but also for the design, plans and specifications, and for the sufficiency of the bridge for the loads specified.

II. The Contractor shall furnish all requisite (in the opinion of the Board) erection plans and details in connection therewith or incidental thereto, to conform with the plans and specifications submitted by the Minister, all of which erection plans and the details in connection therewith or incidental thereto shall be subject to the approval of the Chief Engineer of the Board, and any substitution for, alteration in or modification of any such erection plan or any such details in connection therewith or incidental thereto, shall be subject to the joint approval of the Board and of the Contractor.

III. The Contractor shall furnish strain sheets together with all detailed calculations in connection therewith, or incidental thereto, or in connection with or incidental to the Contract work covered, or intended to be covered thereby, which strain sheets and detailed calculations shall be subject to the approval of the Chief Engineer of the Board, and any substitution for, alteration in or modification of any such strain sheets and any such detailed calculations shall be subject to the joint approval of the Board and of the Contractors.

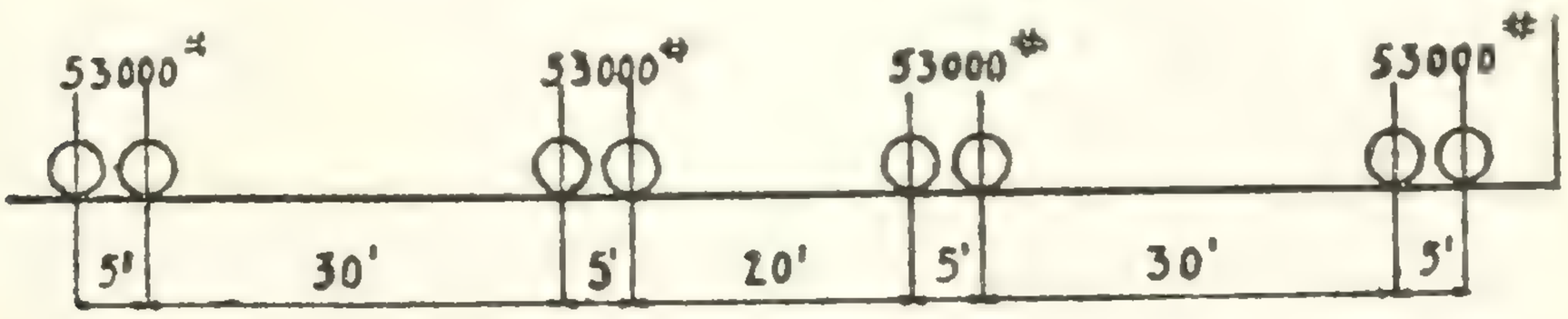
IV. The Contractor shall furnish all shop drawings for the approval of the Chief Engineer of the Board and shall not order or manufacture any materials in connection with or incidental to the Contract work, or any part thereof, or execute any work, covered, or to be covered, by such drawings or any of them, under the Contract, plans and specifications as a part of such Contract, or any of them, until such shop drawings have been first approved by the Chief Engineer of the Board.

9. *Contractor's Plans.*—As mentioned in paragraph 6, Contractors are invited to submit designs of their own, according to this specification, but it is understood that no remuneration of any kind shall be paid by the Minister for the preparation of said plans, whether they be accepted or not.

10. *Duties.*—All duties on material and plant will be paid by the Contractor.

11. *Loads.*—The loads and stresses for which the bridge or some of its parts will be calculated, are as follows:—

A. Train load, Cooper's class E50, on one or two tracks.
B. " " " " E75, on one or two tracks.
C. A highway load on one or two roadways of 40 lbs. per square foot, or 920 lbs. per lineal foot of each roadway.
D. A highway load of 100 lbs. per square foot, or 4,600 lbs. per lineal foot of bridge.
E. Street car load; two 53-ton cars each 60 ft. long and 12 ft. wide.



F. On roadway a concentrated load of 24,000 lbs. on two axles, 10 ft. centres.
G. On highway and sidewalks, a snow load of 30 lbs. per square foot, or 1,500 lbs. per lineal foot of bridge.
H. On highway; dead load above I-beams of 2,970 lbs. for each roadway. See plan attached.
I. Track-load; ties, guard rails weighing 670 lbs. per lineal foot of track. See plan attached.
J. Weight of steel floor (floorbeams, stringers and I-beams—distributed load).
K. Weight of steel-work as erected not included in 'H,' 'I' and 'J,' but including travellers and false work, etc., during erection.
L. A wind load normal to the bridge of 30 lbs. per square foot on the exposed surface of two trusses, floor, and fence (fixed load) and also on travellers and false work, etc., during erection.
M. A wind load of 30 lbs. per square foot on part above fence of a train 14 ft. high (moving load).
N. A wind load equal to ½ ('L' + 'M').
O. A wind load nearly parallel to bridge of 30 lbs. per square foot on the projected area of the steel work and of two trains 14 ft. high on a vertical plane normal to wind, or on travellers, false work, etc., during erection; said load to be taken as acting parallel to bridge.
P. Stresses due to a traction load of 750 lbs. per lineal foot on one track.
Q. Stresses due to a variation of temperature of 150° Fahrenheit.
R. Stresses due to a variation of temperature of 50° between steel-work and masonry.
S. Stresses due to a difference of temperature of 25° between the bottom chords of trusses when free motion is not allowed.
T. Stresses due to difference of temperature of 25° between the outer web exposed to the sun and the other webs of compression members.

12. *Train loads on two tracks.*—The trains on the two tracks shall be assumed to have engines headed in the same direction, and whenever two separate loads give the maximum strains in any member, two trains shall be assumed on each track with length of train and position of engines giving the maximum.

13. The different strains will be calculated and classified under four classes:

I. Live load.
II. Dead load. (Axial and bending.)
III. Wind, temperature and traction.
IV. Secondary.

14. *Secondary strains.*—All strains produced owing to the deformation of the steel-work under any and all loads, either by the absence of pins at the joints or by the friction on pins opposing the turning of members shall be considered as secondary strains.

15. *Loads used to determine section of members.*—The maximum strains due to all the co-existing loads and stresses as per paragraph 11, and to deformation, shall determine the section of the different members with the following restrictions:

Load 'B' will be used only to determine the dimension of the masonry and anchorage and also of the connection of centre span to cantilever arms and of any members where its use would change tension into compression, or vice-versa.

Load 'B' will also be used to establish the outline of the bridge so that the deflection due to the load will always leave the clear height as specified in paragraph 4.

Load 'C' will be used for trusses, main cables and anchorages, only.

Loads 'C,' 'E' and 'F' will be used for floorbeams and stringers, and members receiving their maximum strain from a length of moving load covering two panels or less.

Loads 'L,' 'M' and 'O' will be used with railway tracks loaded and no highway load.

Load 'N' will be used with railway tracks and roadways loaded.

Strains produced by 'T' will be considered as secondary strains, and loads 'S' and 'T' will not be assumed to co-exist with wind loads 'L,' 'M' and 'O.'

Loads 'H' and 'I' will be used for all designs, the plan of floor attached being standard.

16. *Statically indeterminate structures.*—The strains in statically indeterminate structures shall be calculated from their elastic deformations and all assumptions made and formulae used for the calculations must be given.

17. *Plate girders.*—Plate girders shall be calculated by their moments of inertia.

18. *Strain sheets.*—The Contractor offering his own design must furnish complete strain sheets giving the primary and secondary strains under all conditions of load, during and after erection, and when requested to do so, he must, to facilitate checking, furnish in detail the calculations by which his strains were obtained.

19. Separate strain sheets must show all strains:

I. From uniformly distributed dead loads.
II. From all other dead loads.
III. From live loads.
IV. From wind.
V. From temperature.
VI. From traction.
VII. From the maximum co-existing loads.

20. *English units to be used.*—All strains given must be in 1,000 lb. units, and English weights and measures are to be used.

21. *Camber in cantilever.*—The length of all members shall be such that under dead load all panel points shall be in straight lines. Open joints during erection will not be allowed.

22. *Section of members.*—The section of all members must be given in detail on the strain sheets and the radii of gyration of all built up members must be shown.

23. *Plans to be furnished with tenders.*—The plans submitted must show the important connections of the main truss members; the laterals and sway bracings and those of the floor with the trusses; also details of the pedestals and anchorages. The lacing of all compression members must also be shown in detail. The method of erection proposed and the traveller proposed to be used must be clearly shown, so that the erection strains can be readily checked.

The plans submitted will also show all deflections of all parts under the maximum cases of loading specified as per paragraph 11.

The strain sheets and plans submitted must give all the information needed for determining the adequacy and the agreement with the specifications of the proposed design and for judging the difficulties and the time required for the erection.

24. *Estimate of quantities.*—The bids must be accompanied by a detailed estimate of quantities. This estimate must give separately the weight of steel in the cross floorbeams, the steam railway stringers, the highway stringers, and the I-beams above

the roadway stringers; that of the trusses, the bottom and top laterals and the cross bracing, that of the pedestals and the anchorages, and in all trusses the weight of the bottom chords, top chords, web members and pins. In all built members the weight of the body = Σ a $\square''$ x l' x 3.4 (where a $\square''$ is the area in square inches and l' the length in feet from centre to centre of connection) and the remaining weight of the member or group of members must be given separately. Weight of travellers, temporary members and false works, when they affect the strains in the bridge, must also be given.

The weights must be given in sufficient detail so that the assumed dead loads and their distribution over the length of the bridge can be easily and quickly checked. The assumed dead loads and wind pressures and their location must also be given on the strain sheets.

25. *Masonry piers.*—Contractors offering their own plans will also send plans of the masonry abutments and piers required (other than the main piers), subject to this specification.

26. *Time of completion.*—The Contractor will state in his tender the estimated date at which he would guarantee to complete the bridge ready for traffic, it being assumed that the north main pier will be finished on November 1, 1910, and all other masonry November 1, 1911.

27. *Where final plans have to be made.*—To prevent delays, all drawings and strain sheets, after the contract is awarded, shall be made at one place in Canada, and all shop drawings shall be made in full detail according to American practice, using English measures, as per paragraph 20.

28. *Material to be used.*—All steel shall be open hearth. Floor-beams and stringers shall be made of carbon steel, sub-punched and reamed. All other parts in cantilever designs may be made of steel containing 3 to 3½% nickel, drilled throughout. All material in suspension designs shall be carbon steel (see paragraph 31).

The Contractor will state in his tender whether he proposes to use acid or basic steel in all or in parts of the bridge.

29. *Rivets.*—Rivets shall be made of carbon steel.

Their diameter will be at least: ⅞-in. up to 3½ in. grip; 1-in. from 3½ in. to 5½ in. grip; 1⅛ in. for 5½ in. grip and over.

Maximum distance between stitching rivets in compression members to be eight times the minimum thickness of any of the plates or shapes connected together.

30. *Quality of steel.*—The exact quality of steel will be specified later on, but the grade of carbon steel used will be generally as follows:

Structural steel will show an ultimate strength of 62,000 to 68,000 lbs. and a minimum yield point of 37,000 lbs. per square inch.

For rivets 50,000 to 56,000 lbs. ultimate; 30,000 minimum yield point.

Yield point to be determined by drop of the beam.

Speed of machine for testing samples to be such that material under tension will not elongate more than one inch in three minutes.

Structural nickel steel will show 50 % more than carbon steel.

Nickel steel eye-bars in full sized tests will show a minimum ultimate strength of 80,000 lbs. per square inch and a minimum yield point of 42,000 lbs.

31. *Size of Material.*—All plates and shapes shall be of the maximum sizes and thickness obtainable.

No material shall have thickness of less than ½ in. in any of the truss members or towers of suspension bridges. In no case shall any material be less than ⅜ in. in thickness.

All material $\frac{3}{4}$ in. or more in thickness and all nickel steel shall be drilled from the solid after the members are assembled.

32. *Compression members.*—All joints in compression members shall be faced. All splices shall have full strength in material and one-half strength in rivets, except the top and bottom angles, which will be riveted for the full strength.

The unsupported width of plates in compression members must not be more than twenty-four times the thickness.

33. *Pressure of masonry.*—Maximum pressure on bed plates per square inch 800 lbs.; maximum pressure on concrete per square foot, 33,000 lbs.

34. *Anchorage masonry.*—For cantilever designs, anchor piers shall show a coefficient of safety of two.

For anchorages of suspension bridges a coefficient of safety is to be assumed of one and one-half against both uplift and sliding.

The coefficient of friction of masonry on rock is to be taken at 50%, but no part of the rock shall be taken as resisting the anchorage strain, as the mass of masonry only will be taken into account.

35. *Railway tracks.*—The railway tracks will be built as per drawing attached, with two stringers 8 ft. apart under each track.

36. *Stiffening trusses in suspension designs.*—Stiffening trusses shall be designed with single intersection. The centre span truss will be without vertical or horizontal hinge in the centre, discontinuous at towers, hinged vertically and free to slide horizontally at this latter point.

Members of stiffening trusses shall be proportioned for either maximum tension or compression. Connections and splices in all cases shall be proportioned for the sum of both stresses. Abutting joints shall be faced and given full splice in rivets for the sum of both stresses.

37. *Unit strains in suspension bridges.*—Cables 55,000 lbs. per square inch. (Wire of cables to be the same as that used in the Manhattan Bridge in New York.

Carbon steel, tension 16,000 lbs. per square inch.

Carbon steel, compression 16,000—70l/r lbs. per square inch.

Increase units by 10% where secondary strains are included.

38. *Units of strain for cantilever designs.*—A=Live load strains for loads as specified in paragraphs 11, 12, 15; B=Dead load strains; C=All co-existing maximum strains together, except secondary strains; D=All maximum strains including secondary strains.

CARBON STEEL.

Tension Members in Main Trusses.

A	B	C	D
10,000	20,000	20,000	22,000

Suspenders or any Members Liable to Sudden Loading.

A	B	C	D
7,000	14,000	14,000	15,400

Railway Stringers.

A	B	C	D
8,000	16,000	16,000	17,600

Floorbeams and Highway Stringers.

A	B	C	D
9,000	18,000	18,000	19,800

Compression Members in Main Trusses.

A	B	C	D
10,000—$40^{l}/_{r}$	20,000—$80^{l}/_{r}$	20.000—$80^{l}/_{r}$	22.000—$88^{l}/_{r}$

Laterals and Sway Bracing.—Take both systems in calculation of strains, disregarding reversal of strains. Unit=16,000—$70^{l}/_{r}$.

Rivets.

	Bearing.	Shear.
Floorbeams and stringers	12,000 lbs.	6,000 lbs.
Truss members	15,000 "	7,500 "
Laterals and sway bracing	20,000 "	10,000 "

For field rivets reduce above by 10%.

Pins.

Bearing.	Fibre Stress.
24,000 lbs.	24,000 lbs.

Nickel Steel.

Increase units given for carbon steel as follows:

Tension	40%
Compression and pins	25%

But no compression member built of nickel steel shall be strained more than 19,000 lbs. per square inch, not including secondary strains.

Note.—The units giving the maximum section shall be used for proportioning the different members.

39. *Fair wage schedule.*—Parties tendering shall be required to accept the Fair Wage Schedule to be prepared by the Department of Labour for all employed in Canada.

40. *Notice of intention to tender.*—It would be in the interest of the Contractors to notify the Board of Engineers, Quebec Bridge, Canadian Express Building, Montreal, of their intention to submit tenders, so that they may be advised, without loss of time, of any additions or changes which may be made in this specification, before tenders are called for.

H. E. VAUTELET,
Chief Engineer.

MONTREAL, January 1, 1910.

SESSIONAL PAPER No. 104

BOARD OF ENGINEERS, QUEBEC BRIDGE SPECIFICATIONS.

FOR THE CONSTRUCTION OF THE SUPERSTRUCTURE OF A RAILWAY AND HIGHWAY BRIDGE OVER THE ST. LAWRENCE RIVER NEAR QUEBEC.

In these specifications the words 'Minister,' 'Board,' Chief Engineer,' 'Engineer,' 'Work or Works,' shall have the same respective meanings as defined for the purposes of the contract.

1. *Works under contract.*—The works referred to in these specifications consist in the making and building of the superstructure of a railway and highway bridge over the St. Lawrence River near Quebec, complete and ready for traffic, except as otherwise specified in paragraph 14.

2. *Plans.*—The plans mentioned in the schedule hereto attached (hereinafter called the Board's plans) and the notes on same shall be considered as a part of these specifications. In case of disagreement between the plans and specifications, the latter shall govern.

3. *Length of spans.*—The superstructure shall consist as per plan No. 1 of

One deck span 91′0″
One deck span 96′0″
One shore arm 586′0″
One main span 1,758′0″
One shore arm 586′0″
One deck span 115′0″

4. *Contractor's plans.*—In addition to tendering on the Board's plans, Contractors will be allowed to submit tenders on plans of their own or on modifications of the Board's plans, but all tenders shall be subject to these specifications and to the following conditions:

I. The superstructure of the new bridge shall be erected on the two main piers, shown on plan No. 1.

II. The main span shall be 1,758′0″ long, centre to centre of piers, with trusses 88 ft. centre to centre, and a maximum depth of 290 feet.

III. A clear head-room for ships must extend for 600 feet at the centre of the main span and no part of the steel-work, for that length, shall be under Elev. 251.30, with the maximum loading specified, leaving 150 feet clear above highest water.

IV. A clear head-room must extend 23′0″ above base of rail for a width of 29′0″ over the railway tracks; 14′0″ clear for a width of 18′06″ over the roadway on each side of the railway tracks, and 7′0″ clear for a width of 5′0″ over the sidewalks.

V. Plan No. 1 shows the position of the two main piers and of the two existing abutments with elevations. The position and elevation of the two main piers are fixed; the position and elevation of the other piers and abutments may be varied. The grade on any part of the bridge must not be more than one per cent. under all conditions of loading and temperature. The 600 feet at the centre of the main span shall be level under dead load, except for the camber.

VI. No remuneration of any kind will be paid by the Minister for the preparation of plans submitted by intending contractors, whether they be accepted or not.

VII. The lowest or any tender will not necessarily be accepted.

5. *General conditions of Contract.*—The Contractor must satisfy himself as to the sufficiency and suitability of the design, plans and specifications upon which the bridge is to be built, as the Contractor will be required to guarantee the satisfactory erection and completion of the bridge and it is to be expressly understood that he undertakes the entire responsibility not only for the materials and construction of the bridge, but also for the design, calculations, plans and specifications, and for the sufficiency of the bridge for the loads therein specified. And the enforcement of any part or all parts of the specifications shall not in any way relieve the Contractor from such responsibility.

6. *Form of tender.*—No tender will be accepted unless it is strictly in accordance with the printed form supplied for the purpose, and in case of firms, unless it is signed by each member of the firm. The nature of the occupation, and the place of residence of each member of the firm shall be stated. The place or places where the Contractor intends to have the materials for the bridge rolled and manufactured into bridge members shall also be stated in the tender.

7. *Custom duties.*—All Canadian and foreign custom duties on material and plans shall be paid by the Contractor.

8. *Schedule of prices on plans of the Board.*—Tenders must state prices for the work as follows:

I. A price per pound for the steel in the superstructure erected and painted complete, the suspended span being erected by cantilevering out (weight of erection paint, rails or material included in item IV. of this paragraph, or any material needed for erection only, and which does not remain as part of the completed bridge not to be included). The price to be based upon the use of basic open hearth steel, except for cables, which shall be made of acid open hearth steel.

II. An alternate price per pound for material and work covered by item one using acid instead of basic open hearth steel.

III. A lump sum to be paid in addition to the above if the suspended span is floated into position.

IV. A lump sum for concrete, concrete slabs with reinforcing bars, granite, asphalt and paving bricks furnished and laid complete in the roadway floors, for the laying and bonding of electric railway rails, and also for the furnishing of guard angles, with screws and bolts for the railway floor as per plans.

9. *Modifications to the plans of the Board.*—In case the Contractor offers to modify the plans of the Board by changing the length and depth of the cantilever and shore arms, or the length and design of the suspended span, or if the mode of erection he uses decreases the quantities of material as shown on the plans exhibited, he shall state in his tender the amount of weight saved and shall also submit complete proof of such statement.

10. *Weight paid for. (Plans of the Board).*—The Contractor will be paid under item one paragraph (8) eight for the number of pounds of steel remaining in the bridge after all erection material has been removed, but in case such weight exceeds the calculated weight based on the dimensions of material shown on the shop plans (after deducting all erection material) plus two per cent, the Contractor shall be paid for such calculated weight with an addition of two per cent; the weight of paint shall not be included in such calculated weights.

11. *Schedule of prices on Contractor's plans.*—If the Contractor desires to tender on plans prepared by himself, tenders must state prices for the work as follows:

I. A price per pound for the steel in the superstructure erected and painted complete, the suspended span being erected by cantilevering out for a cantilever design (weight of erection paint, rails or material included in item ten of this paragraph, or any material needed for erection only, and which does not remain as part of the completed bridge not to be included). The price to be based on the use of basic open hearth steel, except for cables, which shall be made of acid open hearth steel.

II. An alternate price per pound for material and work covered by item one, using acid open hearth steel instead of basic open hearth steel.

III. A lump sum to be paid in addition to this if the suspended span is floated into position, in the case of a cantilever design.

IV. A price per pound for any additional nickel steel that may be ordered by the Chief Engineer, the price to include cost of erection.

V. A price per pound for any additional carbon steel that may be ordered by the Chief Engineer, the price to include cost of erection.

Items four and five apply only to cantilever designs.

VI. A price per pound for any additional material in the anchorage that may be ordered by the Chief Engineer, the price to include cost of erection.

VII. A price per pound for any additional material in the towers that may be ordered by the Chief Engineer, the price to include cost of erection.

VIII. A price per pound for any additional material in side spans or stiffening trusses that may be ordered by the Chief Engineer, the price to include cost of erection.

IX. A price per pound for any additional material in the cables that may be ordered by the Chief Engineer, the price to include cost of erection.

Items six, seven, eight and nine apply only to suspension designs.

Items four to nine both inclusive, shall apply only to increase in quantities of material ordered by the Chief Engineer and not provided for the specifications as interpreted by him.

X. A lump sum for concrete, concrete slabs, with reinforcing bars, granite, asphalt, and paving bricks, furnished and laid complete in the roadway floors, for the laying and bonding of electric railway rails, and also for the furnishing of guard angles, with screws and bolts for the railway floor as per plans.

12. *Weight of Contractor's design.*—The Contractor shall state in his tender the total weight of steel included in item one or two, paragraph 11, for each design and each mode of erection tendered on.

13. *Weights to be paid for if bridge is built on Contractor's plans.*—The Contractor shall be paid on items one and two as the case may be and on items four to nine inclusive, paragraph 11, at schedule prices for the lowest of the following weights:

(*a*) The finished weight of steel, included in items one or two, paragraph 11.

(*b*) The weight of steel included in items one or two, paragraph 11, calculated from the dimensions of material shown on the shop plans referred to below, plus an addition of two per cent, to the weight so obtained. (The weight of paint shall not be included in the calculations.)

(*c*) The weight stated in the tender.

Provided however that the shop plans on which the weights will be calculated shall be made according to the specifications as interpreted by the Chief Engineer, whose decision shall be final; and the weight of any material shown on such shop plans in excess of the weight of material shown in the Contractor's plans submitted with

the tender shall be deemed to be included in the total weight stated in the tender. But in case the Chief Engineer orders increases in quantities of material not provided for by the specifications as interpreted by him, such increase shall not be deemed to be included in the total weight stated by the Contractor in his tender and shall be paid for at schedule prices as per items four to nine inclusive of paragraph (11) eleven.

14. *Floor materials.*—All rails and materials for railway tracks above stringers will be furnished and laid by the Minister except the expansion joints and guard angles with the screws and bolts therefor, which shall be furnished by the Contractor.

Electric railway rails and standard splices therefor will be furnished by the Minister and laid by the Contractor who will be required to bond the rails and furnish all material necessary for such bonding.

The Contractor shall furnish and build in place all material for expansion joints in highway floors, sidewalks and electric railway tracks.

The cost of all items mentioned in this paragraph as being furnished or laid by the Contractor shall be deemed to be included in item four, paragraph (8) eight, and item ten, paragraph (11) eleven.

15. *Conditions of floating suspended span.*—If a cantilever bridge is built and the suspended span is floated into place, the Minister shall, if the Contractor so desires, provide and place at the disposal of the Contractor such steamship or steamships as will afford sufficient power to tow the suspended span to the bridge site. It is to be distinctly understood, however, that the Minister will only furnish such steamships as will be sufficient to move the said span and the Contractors will have to furnish any additional steamers that may be required to steer or otherwise control the tow. The Contractor will also have to furnish all scows, false work, cables, anchors, tackle, labour or other plant or material that may be required to properly execute the work.

The Contractor will have to assume entire responsibility for the steamship or steamships supplied by the Minister and for the satisfactory carrying out of the work upon which they are employed.

The Minister will, during such time and to such extent as the Chief Engineer considers necessary, stop navigation on the stretch of water required for the floating operations.

16. *Deposit.*—Each tenderer must send with his tender or tenders a cheque accepted by a Canadian chartered Bank for five hundred thousand dollars ($500,000) made payable to the order of the 'Minister of Railways and Canals of Canada.' As soon as a tender is accepted the successful Contractor shall deposit with the Minister another similarly accepted cheque made payable to the order of the Minister for such amount as will make the united amount of the two cheques equal to fifteen per cent (15%) of the cost of the works as estimated by the Chief Engineer.

Time being the essence of the contract, if the Contractor whose tender has been accepted neglects or refuses to sign the contract upon being requested to do so by the Minister or to deposit the second cheque mentioned above, the said sum of five hundred thousand dollars ($500,000) accompanying the tender shall be forfeited by the Contractor and shall become the property of His Majesty the King as liquidated damages.

The total deposit so made by the Contractor shall in any case be held by the Minister as security for the due and faithful performance and completion of the contract to the satisfaction of the Chief Engineer and until the delivery to and acceptance of the works by the Minister.

Interest upon the said deposits at the rate of three per cent (3%) per annum will be paid by the Minister to the successful contractor as provided in the contract.

17. *Prices.*—It is understood that the prices stated by the Contractor in his tender shall be those upon which he agrees to be paid for the works embraced in these specifications. These prices will be held to include all failures, accidents, contingencies, plant, labour, material, staging, painting, customs duties, rental, taxes, transportation, patent rights, cost of leases, necessary buildings, medical attendance, removal of erection and damaged material and everything necessary for the entire completion of the works. Such prices will also be held to include all loss or damage from whatever cause arising that may happen or occur to the works, or any part or portion of them, or to the men, plant, materials or tools.

18. *Mode of payment.*—Payments will be made as follows:

I. On unmanufactured material certified by the Engineer to have been delivered at the shops, 90% of the invoiced price, including freight and duty, as paid by the Contractor.

II. On members certified by the Engineer to have been completely finished in the shops, an additional amount per pound equal to six-tenths of the payment under item one.

III. On manufactured material delivered at the site of the bridge the full amount of transportation, from shop to the bridge site, as shown by invoices and in addition 90% of the duty, if it has not already been paid under item one.

IV. On material erected and partially riveted, to the satisfaction of the Chief Engineer, the balance of the contract price per pound, minus one cent per pound. Payments under this item will, however, only be made on members fully completed between panel points, and after complete riveting of each such member of the trusses; on floorbeams after the two webs have been riveted together; on stringers, laterals and sway bracing when they are fully bolted.

V. As soon as the steel work is completely erected, in place with the exception of riveting and painting, an additional amount of one half cent per pound.

VI. Monthly payments of 90% will be made on the value as estimated by the Chief Engineer of the work done on the concreting, asphalting and other work on the floor.

VII. The lump sum for the floating of the suspended span will be paid on the first monthly estimate after said suspended span is completely and safely connected to the cantilever arms and after the floating supports and anchors have been removed.

VIII. The balance of the contract price will be paid at the same time as the deposits with the Minister are returned to the Contractor.

IX. The basis for calculating the amounts to be paid under the monthly estimates on account of items one and two of this paragraph shall be the average of the invoice prices per pound of the total weights of carbon steel, nickel steel and cable material respectively accepted by the Engineer from the beginning of the work to the end of the period covered by the estimate then being prepared.

X. No payments will be made on any material until it is delivered on premises either leased to or belonging to the Minister and the Contractor will be required to lease to the Minister any shops, mills or other premises in or upon which any material is stored or being manufactured upon which any advance or part payment has been made by the Minister.

XI. The payments mentioned in items one to eight, inclusive, of this paragraph will only be made on material that is to remain in the completed bridge and not on any material required for erection only and which will be removed after the completion of the works.

19. *Monthly estimates.*—No payments will be made to the Contractor except on monthly estimates signed by the Chief Engineer. Estimates will be made up at the end of each month and forwarded to the Minister not later than the 15th of the month following, and payment covering such estimate will be made by the Minister to the Contractor not later than the last day of the same month, after deducting any sums which may be due to the Minister by the Contractor.

20. *Work to be started on both sides of the river.*—The work of erection shall be proceeded with on each side of the river as soon as the main pier is ready. All false work, erection plant and machinery shall be provided in duplicate.

21. *Prosecution of work.*—The work shall be proceeded with as rapidly as possible so as to secure its completion at the earliest date.

22. *Time of completion.*—The Contractor shall state in his tender the date at which he estimates that he will be able to complete the bridge ready for traffic upon the assumption that the north main pier will be finished on November 1st, 1910, and all other masonry November 1st, 1911. The Contractor will be required to guarantee the completion of the work upon such estimated date, subject to any extension or extensions of time that may be granted by the Minister on the recommendation of the Chief Engineer or otherwise. Provided also that if the said piers and other masonry are not finished upon the said respective dates, the Minister shall decide what, if any, extension or extensions of time shall be granted to the Contractor for the completion of the works.

23. *Plans.*—Dimensions where definitely determined, will be marked on all plans exhibited. In no case must dimensions be scaled. All final plans before any materials are ordered from them must bear the signature of the Chief Engineer. All drawings exhibited and all final plans shall be the property of the Minister and no copies of any drawing, blue print or plan, shall be given to any person without the written consent of the Minister or the Chief Engineer.

24. *Test of the completed bridge.*—Before the completed works are delivered to and accepted by the Minister, the Minister may have the works tested under live load. Such live load for the railway tracks shall not be more than Cooper's Class E75, and for the highway not more than 1,840 lbs. per lineal foot of bridge. Such tests loads are to be furnished by the Minister.

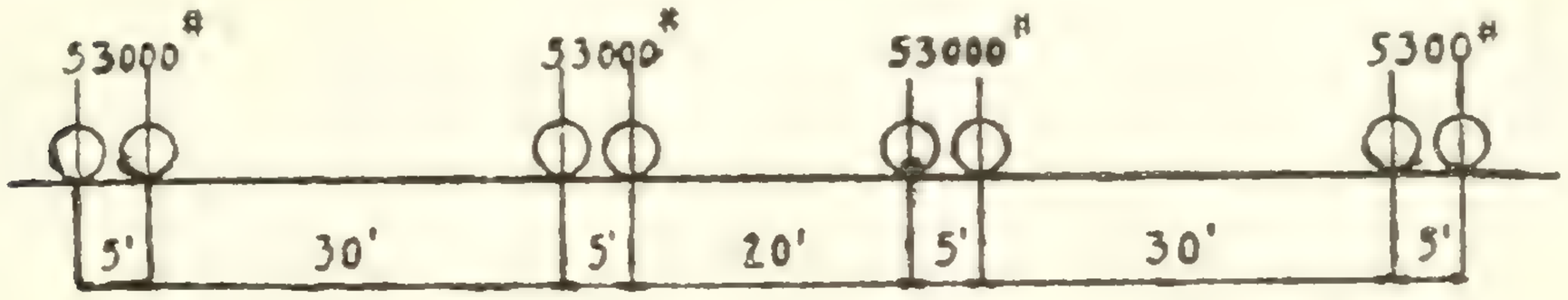
25. *Form of contract.*—Attached to these specifications is a form of the contract which the Contractor will be required to execute for the construction of the work. Blanks have been left in the form for the insertion of the schedule of prices and other particulars that will be supplied by the tender and these specifications.

26. *Specifications for suspension bridge.*—If a suspension bridge design is accepted by the Board, a supplementary specification, giving additional details respecting the cables, suspenders, anchorages, and other matters as are not included in these specifications, shall be furnished by the Chief Engineer. The clauses of the specifications of the Manhattan Bridge built in New York, U.S.A., will, as far as, in the opinion of the Chief Engineer, the same are applicable and are not contrary to these specifications, form the basis of such supplementary specifications.

LOADS.

27. *Loads.*—The loads and stresses for which the bridge or some of its parts will be calculated, are as follows:

A. Train load, Coopers class E50, on one or two tracks.
B. " " " E75, " "
C. A highway and sidewalk load one or two roadways of 40 lbs. per square foot, or 920 lbs. per lineal foot of each roadway.
D. A highway and sidewalk load of 100 lbs. per square foot, or 4,600 lbs. per lineal foot of bridge.
E. Street car load; two 53 ton cars each 60 ft. long and 12 ft. wide on each track.



F. On roadway a concentrated load of 24,000 lbs. on two axles, 10 ft. centres.
G. On highway and sidewalks, a snow load of 30 lbs. per square foot, or 1,500 lbs, per lineal foot of bridge.
H. On highway; deal load above I-beams of 2,300 lbs. per lineal foot for each roadway. See plan No. 2.
I. Track-load; ties, guard rails weighing 670 lbs. per lineal foot of railway track. See plan No. 2.
J. Weight of steel floor (floorbeams, stringers and I-beams—distributed load).
K. Weight of steel-work as erected not included in 'H,' 'I' and 'J,' but including travellers and false work, etc., during erection.
L. A wind load normal to the bridge of 30 lbs. per square foot on the exposed surface of two trusses, floor and fence (fixed load) and also on travellers and false work, etc., during erection.
M. A wind load of 30 lbs. per square foot on part above fence of a train 14 ft. high (moving load).
N. A wind load equal to $\frac{1}{2}$ ('L' + 'M').
O. A wind load nearly parallel to bridge of 30 lbs., per square foot on the projected area of the steel-work and of two trains 14 ft. high on a vertical plane normal to wind, or on travellers, false work, etc., during erection.
P. Stresses due to a traction load of 750 lbs. per lineal foot on one track.
Q. Stresses due to a variation of temperature of 150° Fahrenheit.
R. Stresses due to a difference of temperature of 50° between steel-work and masonry.
S. Stresses due to a difference of temperature of 25° between the bottom chords of trusses when free motion is not allowed.
T. Stresses due to a difference of temperature of 25° between the outer web exposed to the sun and the other webs of compression members.

28. *Train loads on two tracks.*—The trains on the two tracks shall be assumed to have engines headed in the same direction, and whenever two separate loads give the maximum strains in any member, two trains shall be assumed on each track with length of train and position of engines giving the maximum.

29. *Loads used to determine section of members.*—All the coexisting loads and stresses and the deformation shall determine the section of the different members with the following restrictions:

Load 'B' will be used to determine the dimension of the masonry and anchorage and also of the connection of suspended span to cantilever arms and of any members subject to reversal of stresses under live load.

Load 'B' will also be used to establish the outline of the bridge so that the deflection due to the load will always leave the clear height as specified in paragraph 4.

Load 'C' will be used for trusses, main cables and anchorages only.

Loads 'D,' 'E' and 'F' will be used for floorbeams and stringers and members receiving their maximum strain from a length of moving load covering two panels or less.

Loads 'L,' 'M' and 'O' will be used with railway tracks loaded and no highway load.

Load 'N' will be used with railway tracks and roadways loaded.

Strains produced by 'T' will be considered as secondary strains, and loads 'S' and 'T' will not be assumed to coexist with wind loads 'L,' 'M' and 'O.'

Loads 'H' and 'I' will be used for all designs, plan No. 2 of floor being standard.

UNIT STRAINS AND PROPORTION OF PARTS.

30. *Unit strains in cantilever designs.*—All parts of the structure shall be proportioned so that the sum of the maximum strains produced by the loads specified shall not exceed the following amounts in pounds per square inch for carbon steel, when

A=Live load strains for loads as specified;
B=Dead load strains (including snow);
C=All coexisting maximum strains together, except secondary strains;
D=All coexisting maximum strains, including secondary strains.

31. *Tension members in main trusses.*—

A	B	C	D
10,000	20,000	20,000	22,000

32. *Suspenders or any members liable to sudden loading.*—

A	B	C	D
7,000	14,000	14,000	15,400

33. *Wire suspenders.*—

A	B	C	D
22,500	45,000	45,000	49,500

34. *Railway stringers.*—

A	B	C	D
8,000	16,000	16,000	17,600

35. *Floorbeams and highways stringers.*—

A	B	C	D
9,000	18,000	18,000	19,800

36. *Compression members in main trusses.*—

A	B	C	D
$10,000-40l/r$	$20,000-80l/r$	$20,000-80l/r$	$22,000-88l/r$

No compression member built of carbon steel shall, however, be strained more than 15,200 lbs, per square inch, not including secondary strains.

37. *Laterals and sway bracing.*—Take both systems in calculation of strains, disregarding reversal of strains.

For compression. . . . . 16,000—$70l/r$.

38. *Rivets.*

	Bearing.	Shear.
Floorbeams and stringers..	12,000 lbs.	6,000 lbs.
Truss members; Live + Dead..	15,000 "	7,500 "
Truss members; All co-existing maximum strains..	20,000 "	10,000 "
Laterals and sway bracing..	20,000 "	10,000 "

For field rivets reduce above by 10%.

39. *Pins.*—For values of A=10,000 in tension or over, or 10,000—40l/r in compression, and corresponding values of B, C and D, used in calculating the connected member.

Bearing.	Fibre Stress.
20,000 lbs.	24,000 lbs.

For smaller values of A, reduce in proportion.

40. *Nickel steel.*—Increase units given for carbon steel as follows:

Tension..	40%
Compression and Pins..	25%

No compression member built of nickel steel shall, however, be strained to more than 19,000 lbs. per square inch, not including secondary strains.

41. *Units for determining sections.*—The units giving the maximum section shall be used for proportioning the different members.

42. *Unit strains in suspension bridges.*—

Cables..	55,000 lbs.
Carbon steel, tension..	16,000 "
Carbon steel, compression..	16,000—70l/r

Increase units by 10% where secondary strains are included.

43. *Pressure on masonry.*—

Maximum pressure on bed plates per square inch.. ..	800 lbs.
Maximum pressure on concrete per square foot..	33,000 "

44. *Anchorage masonry.*—For cantilever designs, anchor piers shall show a co-efficient of safety of two.

For anchorages of suspension bridges a co-efficient of safety is to be assumed of one and one-half against both uplift and sliding.

The co-efficient of friction of masonry on rock is to be taken at 50%, but no part of the rock shall be taken as resisting the anchorage strain, as the mass of masonry only will be taken into account.

45. *Assumptions and calculations.*—In case of dispute before and after the contract is awarded, the assumptions to be made and modes of calculation to be used, shall be the ones made and used in the preparing of the plans exhibited, and the results of which are shown in the strain sheets and plans exhibited. The decision of the Chief Engineer on any such questions shall be final.

46. *Signs '+' and '—'.*—In all strain sheets the sign '+' shall denote compression; the sign '—' shall denote tension.

47. *Statically indeterminate structures.*—The strains in statically indeterminate structures shall be calculated from their elastic deformations and all assumptions made and formulæ used for the calculations must be given in strain sheets submitted with tenders.

48. *Bending strains.*—All bending strains produced by the weight of the member itself and by loads applied on the member shall be considered as primary strains.

All members shall be proportioned so that the greatest fibre strain due to this bending and axial strain together will not exceed the allowed units for the axial tension or compression in that member.

49. *Secondary strains.*—All strains produced owing to the deformation of the steel-work under any and all loads, either by the absence of pins at the joints or by the friction on pins opposing the turning of members shall be considered as secondary strains.

50. *Alternate strains.*—Members subject to alternate tension and compression shall be proportioned for either stresses. Rivets in connections and splices in all cases shall be proportioned for the sum of both stresses. Material in connections and splices shall be proportioned to resist the larger stress + 25% of the smaller stress. In no case shall the section be less than the section of the member.

51. *Net section at rivets.*—In calculating the net area of tension members, the rivet holes shall be taken one-eight inch larger than the nominal diameter of rivets before driving.

52. *Rivets.*—In proportioning rivets, the diameter of the rivet before driving shall be used.

53. *Splices in tension members.*—Tension members shall be given full splice in material and rivets.

54. *Splices in compression members.*—All splices in compression members shall be given full strength in material and one-half strength in rivets, except the top and bottom flanges which shall be given full strength in material and rivets.

55. *Net section at pins.*—Pin-connected riveted tension members shall have a net section through the end pin hole at least thirty-three per cent (33%) in excess of the net section of the body of the member and the net section back of the pin hole parallel with the axis of the member, shall not be less than eighty per cent (80%) of the net section of the body of the member. The section through the intermediate pin holes shall be increased over that of the member by the section cut out by the pin hole.

56. *Latticing.*—The latticing for compression members shall be calculated by assuming the value of $K^{l/r}$ in the column formula $Uk=U-K^{l/r}$ to be the maximum bending strain in the column produced by its compression. It shall also be assumed that the column will bend in a parabola. If the weight of the member produces additional shear, this must be added.

The same column formula used in proportioning the section of the member shall be used for its lattice bars. When the value of $^{l/r}$ for the parts of struts connected by lattice bars is more than the value of $^{l/r}$ for the whole strut, the former value shall be used in the calculation of the value of the strut.

57. *Plate girders.*—Plate girders shall be proportioned by their moment of inertia.

58. *Compression flange.*—The gross section of the compression flange shall not be less than the gross section of the tension flange, and the width of the flange shall not be less than one-twelfth (1-12th) of the distance between its side supports.

59. *Flange rivets.*—The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the depth of the girder at that point, and in addition any load applied directly on the flange. The wheel loads where the ties rest on the flanges shall be assumed to be distributed over three ties.

60. *Web stiffeners.*—Stiffeners shall be riveted to the web as shown in the plans exhibited.

61. *Radius of gyration of compression members.*—Minimum radius of gyration shall be one one-hunderdth (1-100th) of the length of member for trusses, and one one-hundred and twentieth (1-120th) for lateral and sway bracing struts.

62. *Materials to be used.*—Approach spans, floorbeams, stringers, buckle plates, hand railings, stairways and all rivets shall be made of carbon steel. In case the main part of any member of the trusses is made of nickel steel, all the details and connections of such member shall also be nickel steel. In case the main part of any other member of the bridge is made of nickel steel, the details and connections may be made of carbon steel.

All material in suspension designs shall be carbon steel.

DETAILS OF DESIGN.

63. *Open sections.*—Details shall be so designed that all parts will be accessible for inspection, cleaning, painting and repairs.

64. *Water pockets.*—Pockets or depressions which will hold water shall be provided with satisfactory drain holes, or be filled with acceptable waterproof material.

65. *Symmetrical sections.*—Main members shall be so designed that the neutral axis will be as near as practicable in the centre of section, and the neutral axis of intersecting main members of trusses shall meet at a common point.

66. *Adjustable members.*—Adjustable members shall not be allowed except for erection purposes.

67. *Strength of connections.*—The strength of connections shall be sufficient to develop the full strength of the member, even though the computed strain is less, the kind of strain to which the member is subjected being considered.

68. *Size of material.*—All plates and shapes shall be of the maximum sizes and thickness obtainable.

69. *Minimum thickness.*—No material shall have a thickness of less than $\frac{1}{2}$ inch for all parts of main trusses, carrying calculated strains, except lattice bars which may be 7-16 in. and lattice angles which may be $\frac{3}{8}$ in. The webs and flanges of floorbeams shall have a minimum thickness of $\frac{1}{2}$ inch.

In no case shall any material be less than $\frac{3}{8}$ in. except fillers. Lacing angles of top laterals and sway bracing, may be 5-16 in.

70. *Minimum size of rivets.*—The nominal diameter of rivets shall be at least:

⅞ in. up to 3½ in. grip;
1 in. from 3½ in. to 5½ in. grip;
1⅛ in. for 5½ in. grip and over.

and the actual diameter of the holes shall be 1-16 inch larger.

The actual diameter of the rivets will be such as to require, when heated, a slight pressure to force them into the hole. The size of the rivets shall be adjusted to fill this condition.

71. *Pitch of rivets.*—The minimum distance between centres of rivets shall be three diameters of the rivet holes.

The maximum pitch in the angles in the line of strain for members composed of plates and shapes shall be five diameters of the rivet holes. For angles with two gauge lines the maximum shall be twice the above in each line, with rivets staggered.

The maximum distance between stitching rivets in compression members shall be eight times the minimum thickness of any one of the plates connected together.

The maximum distance between stitching rivets on the edges of tension members shall be ten times the minimum thickness of any one of the plates connected.

72. *Edge distance.*—The minimum distance from the centre of any rivet to a rolled or planed edge shall be 1¼ times the diameter of the rivet hole. The maximum distance from any edge shall be eight times the minimum thickness of any one of the pieces connected, but shall not exceed six (6) inches.

73. *Pitch at ends.*—The pitch at the ends of built compression members shall not exceed four diameters of the rivet holes for a length equal to one and one-half times the depth of the member.

74. *Tension members.*—In pin-connected designs of cantilever bridges, eyebars shall be used for all main tension members where no reversal of strains occurs, except in the first panel of top chord and the first main tension member in the webs of the cantilever and anchor arms, near the main piers where built eyebars may be used and also in the end suspenders of the suspended span, where wire cables may be used.

75. *Riveting of floorbeams to posts.*—The holes in floorbeams for the rivets connecting them to the posts shall be drilled through templets on lines so inclined that, after riveting, the end moment in floorbeams is zero under full dead load and half live load.

76. *Compression members.*—The thickness of plates in compression members shall not be less than 1-24th of the distance between the lines of rivets connecting them to the flanges.

77. *Tie plates.*—The open sides of compression members shall be provided with lattice and shall have tie-plates as near each end as practicable. Tie-plates shall be provided at intermediate points where the lattice is interrupted. In main members, carrying calculated strain, the end tie-plate shall have a length not less than the distance between the lines of rivets connecting them to the flanges, and intermediate ones not less than half the distance.

78. *Lattice.*—Double lattice shall be used for all main members in trusses.

The length between rivets of flat lattice bars shall not be more than thirty (30) times their thickness. In secondary truss members and lateral struts single lattice may be used in which case the length between rivets of flat lattice bars shall not be more than forty (40) times their thickness. The inclination of lattice bars with the

axis of the member shall be about 45 degrees for double lattice and 60 degrees for single lattice.

79. *Faced joints.*—Abutting joints in compression members shall be faced.

80. *Pin plates.*—Pin holes shall be reinforced by plates when necessary and at least one plate shall be as wide as the flanges will allow so that the allowed pressure on the pins shall not be exceeded, and so that the strains shall be properly distributed over the full cross section of the member. These reinforcing plates must contain enough rivets in front of the pin to transfer their proportion of the bearing pressure.

81. *Forked ends.*—When forked ends are used they shall be made of at least twice the sectional area of the member, and at least as strong as the body of the member.

82. *Pins.*—Pins shall be long enough to ensure a full bearing of all the parts connected upon the turned body of the pin. They shall be secured by chambered nuts or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the ends.

83. *Filling rings.*—Members packed on pins shall be held against lateral movement. Filling rings shall have two one-inch holes with tap screws to allow shield to be forced in.

84. *Expansion.*—Provision shall be made for the expansion produced by a variation of temperature of 150° Fahrenheit.

85. *Rigid bracing.*—Lateral, longitudinal and transverse bracing in all structures shall be composed of rigid members, at least as substantial as those shown on the Board's plans.

86. *Overhead transverse bracing.*—Transverse frames rigidly connected to posts and chords shall be used at each main post and at the ends of the through portion of the bridge. They shall be as deep as the clearance will allow. Other transverse frames shall be used at all points where needed.

87. *Length of bracing.*—All lateral and sway bracing between compression members shall be made at least $\frac{1}{4}$ in. short between field connections.

88. *End bracings.*—Deck spans shall have transverse bracing at each end, proportioned to carry the lateral load to the support.

89. *Bracing to clear ties.*—Lateral bracing in deck spans shall be far enough below the flanges to clear the ties in all cases.

90. *Top flange coven.*—Where flange plates are used, one cover plate of top flange shall extend the whole length of the girder.

91. *Web stiffeners.*—Web stiffeners shall be in pairs. Those over the end bearings shall be on fillers. The outstanding legs shall be as wide as the flange angles will allow, and they shall be brought to a close bearing against the upper and lower flange angles. Intermediate stiffeners shall be crimped over the flange angles. Their outstanding legs shall be not less than 1-30th of the depth of the girder, plus two inches. The thickness of all stiffeners shall be not less than $\frac{3}{8}$ in. and the rivet pitch in them shall be not over 5 in.

92. *Camber.*—The length of all members of the cantilevers shall be such that under dead load all panel points shall be in straight lines. For the suspended span they shall be in straight lines under maximum loads covering the entire span.

93. *Open joints during erection.*—Open joints during erection shall not be allowed in any part of the trusses.

94. *Eyebars.*—The eyebars composing a member shall be parallel to the axis of the truss. In case this is found impossible permission to use a maximum inclination of any bar limited to 1 in. in 16 feet must be obtained from the Chief Engineer.

95. *Number and size of wire suspenders at end of suspended span.*—The suspenders shall be made of the size required to meet the specifications. The number of suspenders shown on the drawings exhibited shall preferably be increased, when shop details are made so as to keep their diameter under two and one-half inches if practicable.

96. *Size of wire.*—The wire used shall not be less than No. 8 U.S. gauge.

97. *Wire splices.*—The suspenders will preferably be made without intermediate splices. If this be found impossible on account of the length of wire required, the splices shall have a strength of at least 95 per cent of the ultimate strength of the wire, so made that they will resist the tendency to open or part during the operation of winding.

98. *Size of splices.*—The splice may consist of a sleeve not more than $\frac{3}{8}$ inches in diameter with right and left-hand threads, the wires for shop splices having cold-rolled threads and mitred ends for locking the splice. All splices shall be carefully soldered in a manner acceptable to the Engineer.

99. *Stiffening trusses in suspension designs.*—Stiffening trusses shall be designed with single intersection. The centre span truss will be without vertical or horizontal hinge in the centre, discontinuous at towers, hinged vertically and free to slide horizontally at this latter point.

Members of stiffening trusses, subjected to reversal of stress, shall be proportioned for either maximum tension or compression. Rivets in connections and splices, in all cases, shall be proportioned for the sum of both stresses. Material in connections and splices shall be proportioned to resist the larger stress + 25% of the smaller stress. In no case shall the section be less than the section of the member. Abutting joints shall be faced.

100. *False works on concrete pedestals.*—All false work shall rest on concrete pedestals built at least five (5) feet deep into the ground.

101. *Permanent strairways, &c.*—The Contractor shall design, provide and erect permanent stairways with hand railings on both sides of the bridge at each end portal of the anchor arms and suspended span, giving access from the floor to the top chords, and also one permanent staircase leading from the floor to the top of each main and anchor pier, or twelve in all.

The Contractor shall also design, provide and erect a permanent walk with hand railings on each side, for the whole length of both top chords and across the ends of the suspended truss and anchor arms and across the bridge at the main posts over both main piers.

The permanent stairs shall be made of checkered steel or cast iron, and the walks of wood, all firmly held in place.

Hand railings may be made of wire ropes supported on steel standards securely held in position.

102. *Traction brakes.*—The Contractor shall also provide and erect, between the suspended span and the cantilever arms, effective brakes to prevent motion of the suspended span under traction forces.

103. *Modification to plans exhibited.*—If possible, all top chord supports shall be given the same appearance in elevation, and all top laterals be given the same depth.

STRAINS SHEETS, PLANS AND QUANTITIES.

104. *English units to be used.*—All strains given must be in 1,000 lbs. units, and English weight and measures are to be used.

105. *Erection plans.*—All tenders on the Board's and Contractor's designs must be accompanied by plans showing clearly the method of erection and traveller proposed, so that erection strains may be readily checked.

106. *Strain sheets.*—The Contractor offering his own design must furnish complete strain sheets giving the primary and secondary strains under all conditions of load, during and after erection, and when requested to do so, he must, to facilitate checking, furnish in detail the calculations by which his trains were obtained.

Separate strain sheets must show all strains:

I. From uniformly distributed dead load;
II. From all other dead loads;
III. From live load:
IV. From wind;
V. From temperature;
VI. From traction;
VII. From the maximum co-existing loads.

107. *Section of members.*—The section of all members must be given in detail on the strain sheets and the radii of gyration of all built up members must be shown.

108. *Plans to be furnished with tender on contractor's plans.*—The plans submitted must show the details of the make-up of all truss members and their splices, of the floor, of the laterals and sway bracings and all connections, of the lacing of all compression members and of the pedestals anchorages.

The plans submitted must also show all deflections of all parts under the maximum cases of loading specified.

The strain sheets and plans submitted must give all the information needed for determining the adequacy and the agreement with the specifications of the proposed design and for judging the difficulties and the time required for the erection.

109. *Estimate of quantities on Contractor's design.*—The bids must be accompanied by a detailed estimate of quantities. This estimate must give separately the weight of steel in the cross floorbeams, the steam railway stringers, the highways stringers, and the I-beams above the roadway stringers; that of the trusses, the bottom and top laterals and the cross bracing, that of the pedestals and the anchorages, and in all trusses the weight of the bottom chords, top chords, web members and pins. In all built members the weight of the body $= \Sigma\, a \times l' \times 3.4$ (where a is the area in square inches and l' the length in feet from centre to centre of connection) and the remaining weight of the member or group of members must be given separately. Weight of travellers, temporary members and false works, when they affect the strains in the bridge, must also be given.

The weights must be given in sufficient detail so that the assumed dead loads and their distribution over the length of the bridge can be easily and quickly checked. The assumed dead loads and wind pressures and their location must also be given on the strain sheets.

110. *Quality of material used in contractor's cantilever designs.*—The plans shall show for all parts of the trusses and bracing whether the material intended to be used shall be nickel steel or carbon steel; wherever such information is lacking, the material intended to be used will be assumed to be nickel steel.

111. *Masonry piers.*—Contractors offering their own plans will also send plans of the masonry abutments and piers required (other than the main piers), subject to these specifications.

112. *Railway tracks.*—The railway tracks will be built as per drawing exhibited, with two stringers 8 ft. apart under each track.

113. *Strain sheets and plans after contract is awarded.*—I. As soon as the contract has been awarded the Contractor shall furnish all erection plans, strain sheets and deformation diagrams and details in connection therewith or incidental thereto, to conform with the plans and specifications submitted or accepted by the Minister, all of which erection plans and the details in connection therewith or incidental thereto shall be subject to the approval of the Chief Engineer, and any substitution for, alteration in or modification of any such erection plans, submitted or approved by the Minister, shall be subject to the joint approval of the Board and the Contractor.

II. The Contractor shall furnish strain sheets and deformation diagrams together with all detailed calculations in connection therewith, or incidental thereto, or in connection with or incidental to the contract work covered, or intended to be covered thereby, which strain sheets, diagrams and detailed calculations shall be subject to the approval of the Chief Engineer, and any substitution for, alteration in or modification of any such strain sheets, diagrams and any such detailed calculations shall be subject to the joint approval of the Board and of the Contractor.

III. The Contractor shall furnish all shop drawings for the approval of the Chief Engineer and shall not order or manufacture any materials in connection with or incidental to the contract work, or any part thereof, or execute any work, covered, or to be covered by such drawings or any of them, under the contract, plans and specifications as a part of such contract, or any of them, until such shop drawings have been first approved by the Chief Engineer.

114. *Size of plans.*—All plans, strain sheets, &c., made by the Contractor after the contract is awarded, shall be made on sheets of uniform width.

115. *Where final plans have to be made.*—To prevent delays, all drawings and strain sheets, after the contract is awarded, shall be made at one place in Canada, and all shop drawings shall be made in full detail according to the best American practice, using English measures.

The principal assistant engineer, with a sufficient staff, may be sent to the place where the drawings and strain sheets, referred to above, are made, so as to check all calculations and plans without delay; in which case, the Contractor, at his own cost, shall provide such staff with a private office and such desks, seats, tables, chests of drawers for plans, &c., as will be found necessary for the proper performance of their work.

116. *Erection strain sheets and plans.*—The erection plans shall show all travellers, machinery, lifting tackle, gripping apparatus, temporary members, false work, &c., in full detail so that their weight may be accurately ascertained. Every stage of erection shall be carefully planned showing position of travellers, locomotives, cars and other loads, so that the strains in the different permanent members of the bridge, temporary members and false works, as well as the stability of the structure and

false work, under maximum conditions of loading, wind and temperature, may be fully provided for.

117. *Dimensioning of truss members for erection strains.*—In dimensioning truss members for erection strains the calculated weights of travellers, locomotives, cars, &c., shall be increased 10% to cover any inaccuracy in the estimated loads. This, however, shall not apply to wind loads.

118. *Final strain sheets.*—Strain sheets shall be made by the Contractor in at least as much detail as in the strain sheets exhibited, for all loading separately, and also added together, as per these specifications. Such strain sheets shall be corrected from time to time as the work proceeds on the shop and erection plans.

They shall be considered complete and satisfactory, and approved only when the exact weights and loads have been ascertained and checked by the Chief Engineer.

119. *Shop plans.*—Shop plans shall be approved only when they have been made to conform with the strain sheets and when such plans and strain sheets agree absolutely.

120. *Floating the suspended span.*—The suspended span as shown on drawing No. 1 and the detail drawings exhibited, has been designed for erection by cantilevering out. If said span be floated, its calculation, shape and design shall be altered, approximately as shown on drawing 1a, to meet the new conditions of erection, and the calculations and plans of the cantilevers altered for the new design.

121. *Copies of plans to be furnished by Contractor.*—The Contractor shall furnish the Minister with five copies of all plans made for or in connection with this work, as well as all copies needed by the inspectors. At least two of the copies to be furnished shall be made on blue print linen. The Contractor shall also furnish the Minister with three copies of all invoices.

WORKMANSHIP.

122. *General.*—All parts of the works be built in accordance with the approved plans.

The workmanship and finish shall be the best that the most suitable modern machinery and skilled labour to be obtained can give, to meet these specifications.

123. *Straightening material.*—Material shall be thoroughly straightened in the shop by methods that will not injure it, before being laid off or worked in any way.

124. *Planed edges.*—All sheared edges shall be planed off at least $\frac{1}{8}$ in.

125. *Rolled edges.*—Rolled edges through which strains are transmitted by bearing shall be treated like sheared edges.

126. *Sub-punched and reamed work.*—Members made entirely of carbon steel, except I-beams, may be sub-punched and reamed, but no punching shall be allowed on material over 11-16 in. thick.

127. *Drilled work.*—All members built partly or entirely of nickel steel, all I-beams and all carbon steel more than 11-16 in. in thickness shall have all holes drilled after assembling, and all parts not riveted before shipping match-marked.

128. *Templets.*—The templets shall not be applied to any material unless it is perfectly straight. They must lay flat without any distortion while the marking is being made.

129. *Reaming.*—Punched holes shall be made with a punch 3-16 in. smaller in diameter than the nominal size of the rivets and shall be reamed to a finished diameter of not more than 1-16 in. larger than the rivet.

130. *Reaming after assembling.*—Reaming of punched holes shall be done after the pieces forming one built member have been assembled and firmly bolted together to the satisfaction of the inspector.

Holes for field connections other than field splices of main members shall be reamed or drilled, as the case may be, to a steel templet at least one inch thick.

Reaming shall be done with twist drills working without vibration so as to obtain a hole perfectly cylindrical and perpendicular to the plane of the metal.

If it be necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be allowed.

131. *Removing burrs and fins.*—Before assembling and after drilling, reaming and planing, all burrs and fins shall be removed from punched, drilled or reamed holes and sheared edges.

132. *Size of rivets.*—The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet.

133. *Punching.*—The diameter of the die shall not exceed that of the punch by more than 1-16th of an inch.

Punching must be accurate so that all parts of the hole shall be cut by the reamer.

134. *Use of large rivets.*—Wherever in riveted work the punching is not close enough to permit the reamer to properly clean up all parts of the holes, such holes must be reamed out for the next larger sized rivets. When holes cannot be cleaned up for the next larger sized rivets, the parts inaccurately punched shall be rejected.

135. *No heavy drifting.*—Under no circumstances will heavy drifting be permitted.

136. *Planing edges.*—All plates shall be strongly held against displacement when edges are being planed.

137. *Drilling rivets holes in built members.*—All drilling shall be done after the pieces forming one built member have been assembled and firmly held together.

Drilling shall be done with machines working without vibration so as to obtain a hole perfectly cylindrical and perpendicular to the plane of the metal.

Drills shall be sharpened often enough so as to leave a smooth surface to the interior of the hole and shall be rejected when they are worn out to 1-64th in. below gauge.

138. *Drilling rivet holes in splices.*—When compression members are spliced on both sides, the splicing material on one side shall be drilled with one of the spliced portions of the member and the splicing material on the other side shall be drilled with the other portion of the member. The two portions of the member shall then be faced, if required, and assembled together to exact length and held firmly in position; the half drilled splicing material shall then be bolted securely in place and the blind holes drilled through the holes of the member as a templet.

139. *Members to be straight.*—The several pieces forming one built member shall be straight and fit closely together, and finished members shall be free from twists, bends and open joints.

140. *Assembling compression members.*—All compression members between end pins shall be completely assembled in the shops. The different parts shall be firmly held together by turnbuckles before the final drilling of splicing material. Before taking apart, all pieces shall be permanently match-marked. The shoes and such other parts of the work as the Engineer shall deem necessary to assemble completely in the shop, to insure proper fit in the field, shall be so assembled.

141. *Finish of joints.*—After the whole member between splices is assembled and completely riveted up with splice holes bolted, abutting joints in compression members shall be truly faced so as to have even bearings when perfectly aligned.

This facing on the main members of the trusses shall be done with planing machines. Rotary cutters shall not be allowed.

142. *Web stiffeners.*—The ends of stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

143. *Splice plates and fillers.*—Web splice plates and fillers under stiffeners shall be cut to fit exactly between flange angles.

144. *Web plates.*—All buckled web plates shall be rejected. Web plates of girders which have no cover plates, shall not project above the angles and never be more than 1-16 in. below a true plane coincident with the roots of the angles.

145. *Connecting angles.*—The outstanding legs of all connection angles, connecting stringers to floorbeams or floorbeams to posts, chords, or other members, must not exceed an angle of 90° by more than $\frac{1}{8}$ in. at the end of the longer leg.

In fitting these angles to the stringers or floorbeams, they shall be so fitted that the exact length is measured to the root of the angles, the two roots being in exactly the same plane. The entire end of the assembled member shall then be faced, so as to provide against any reduction of area of the angle at the root by such facing, and in such a way as to secure a true surface for the whole width of the connection, and to allow all parts to be drawn together without any strain in the rivets.

146. *Assembling before riveting.*—Riveted members shall have all parts well pinned up and firmly drawn together with a sufficient number of bolts before riveting is commenced. Care shall be taken to see that no clips from drilling or reaming have been left between the different parts. The surfaces coming in contact shall each be painted before being bolted together.

147. *Rivet forges.*—Rivets, both in the shop and in the field, shall be heated in oil, gas or hard coal furnaces of a form approved by the Engineer. Hand forges can be used only in special cases by permission of the Engineer.

148. *Heating rivets.*—The rivets shall be heated in the furnace at the highest possible temperature without burning, and must be driven without delay. The head of the rivet must be at least at the same temperature as the body. Rivets that 'split' on being taken from the furnace shall be thrown away.

Any rivet heater who is not able to heat the whole of the rivet at the same bright heat without burning, shall be immediately discharged.

149. *Removing scale.*—Before the hot rivet is put in place any scale formed during heating shall be removed.

150. *Driving rivets.*—Rivets shall be driven by pressure tools. Where this is found impossible pneumatic hammers shall be used. As soon as the pressure becomes inadequate, riveting must stop until the pressure has been raised.

151. *Rivets.*—The rivet heads must be hemispherical and of uniform size, for the same sized rivets, throughout the work. They must be full and neatly made and even show a small rounded burr to prove that the rivet was long enough. If the burr so formed is unsightly, it shall be neatly cut with a hand chisel. Heads must be concentric with the rivet holes and the connected pieces thoroughly pinched together. Caulking or recupping is expressly forbidden.

152. *Snaps.*—The snaps used shall be of a pattern approved by the Engineer. They must have flat edges to prevent cutting into the plates and when in use must be normal to the surface of the member.

153. *Bad rivets.*—All rivets with crooked or cracked heads, or heads not formed centrally on the shank, or rivets which are loose, either in the hole or under the shoulder shall be removed as soon as marked by the inspector, and replaced.

154. *Cutting rivets.*—If it is found that the cutting and removing of rivets spoils the holes or the material, the rivets shall be removed by drilling.

155. *Discharging riveters.*—Any gang of riveters in whose work too many defective rivets are found will not be allowed to do any further riveting on these works.

156. *Dollys.*—All dollys shall be cup dollys to fit the rivets heads, as no flat heads will be allowed except where specified on the shop plans.

157. *Eyebars.*—Eyebars shall be straight and true to size, neatly and smoothly finished, and shall be free from twists, folds in the neck or head, or any other defect. All small cracks in the heads or neck shall be carefully cut out, and if found too deep shall cause the bar to be rejected. Heads shall be made by upsetting, rolling or forging, but no patching at the forge fire will be allowed on bar or head.

Welding will not be allowed.

The forms of heads will be determined by the dies in use at the works where the eyebars are made, if satisfactory to the engineer, but the Contractor shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck (unless authorized by the Chief Engineer before the drawings are made) shall be at least equal to and shall not exceed, by more than $\frac{1}{8}$ inch, the thickness of the bar.

The heads shall be neatly and smoothly finished to the size and form given on the approved shop drawings, and be symmetrical about the axis of the bar.

158. *Boring eyebars.*—Before boring, each eyebar shall be properly annealed and carefully straightened. Pin holes shall be in the centre line of bars and in the centre of heads. The eyebars of each panel shall be piled on each other at the shops and the pins for which they are bored shall be passed through the holes at both ends of the bars at the same time without forcing.

159. *Annealing.*—Air quenching and annealing in special gas furnaces may be specified before the date at which the tenders are to be received. If no such specification be issued the choice of the mode of annealing will be left to the Contractor.

160. *Gradual heating.*—The bars must be gradually raised to the required temperature for upsetting or annealing, and not thrust cold into a highly heated furnace.

161. *Wire suspenders.*—The method of making the strands shall be selected by the manufacturer, but must be approved by the Chief Engineer, and give, in full size tests, the specified requirements.

162. *Binding strands.*—When all the wires have been laid in place around the shoes, under suitable and even tension, they will be bound together by bands to keep them in their proper position.

These bands will be composed of five or six turns of No. 10 U.S. gauge wire, securely locked and will be placed at intervals not to exceed two feet.

163. *Cable shield.*—The cable shield for filling the interstices between the wires of the strands shall be some form of neutral mineral oil or other material of composition and consistency approved by the engineer. It shall be applied so as to thoroughly and permanently fill the interstices between the wires.

164. *Straining before boring.*—All suspenders before boring shall be put under a tension of at least 40,000 lbs. per square inch for at least one hour, with the shoes securely attached.

The shoes shall then be bored under an even tension for all suspenders of about 10,000 lbs, per square inch.

To ascertain the probable stretch of such suspenders the manufacturer, at his own cost, shall first furnish, build and test, one after the other, so as to remedy possible defects, three suspenders of the length prescribed and ascertain their stretch under loads of 10,000, 20,000, 30,000 and 40,000 lbs. per square inch. In case of non-uniformity in the results, the manufacturer, at his own cost, shall furnish, build and test additional suspenders until sufficient uniformity be obtained.

165. *Covering of suspenders.*—The suspenders shall be thoroughly protected from the weather. The protection shall be so designed in as many parts as will make them easy to handle and so that they may be readily removed to allow inspection of all parts, and easily put back in place.

166. *Pin holes.*—Pin holes shall be bored true to gauges, smooth and straight, and at right angles to the axis of the member and parallel to each other.

The boring shall be done at one operation on the entire members after all the shop riveting has been completed.

167. *Location of pin holes.*—All pin holes shall be drilled in their exact positions within 1-32 in. and any templets or other means or apparatus required for checking said positions, without any chance of error over 1-32 in., shall be furnished by the Contractor.

168. *Measurement of members with pin holes.*—Measurements of lengths of members with pin holes shall be taken between bearing surfaces of such pin holes and not centre to centre.

169. *Size of pin holes.*—The diameter of pin holes shall be 1-50th in. larger than that of the pin for pins up to six (6) in. diameter and 1-32nd in. for larger pins.

170. *Pins over six inches diameter.*—Pins over 6-inch diameter shall be forged and must be sufficiently worked under the hammer to insure sound material.

171. *Pins and rollers.*—Pins and rollers shall be accurately turned to gauge and shall be straight and smooth and entirely free from flaws. All pins over six (6) inches shall have holes at least two (2) inches in diameter, drilled exactly in the centre.

172. *Castings.*—All castings shall be steel castings and shall be annealed.

173. *Welds.*—Welds in steel will not be allowed.

174. *Bed plates.*—Expansion bed plates shall be placed true and smooth. Cast wall plates shall be planed top and bottom. The cut of the planing tool shall correspond with the direction of expansion.

175. *Pilot nuts.*—Pilot and driving nuts shall be furnished for each size of pin, in such numbers as may be ordered.

176. *Shipping details.*—Pins, nuts, bolts, rivets and other small details shall be boxed or crated.

177. *Weight.*—The weight of every piece and box shall be marked thereon in plain figures.

178. *Standard tapes.*—All tapes or other measuring apparatus shall be tested so as to absolutely conform to the chosen standard. Tapes shall be standardized lying flat and supported on their entire length under a tension of ten (10) pounds.

179. *Tension on tapes.*—All measurements shall be made with tapes lying flat and supported at frequent intervals, firmly held at one end and under a permanent tension of ten (10) pounds.

All important measurements shall be made by the Engineer himself.

180. *All tapes to be furnished by the Contractor.*—All tapes and attachments needed by inspectors in the shops and during erection shall be furnished by the Contractor.

SHIPPING AND ERECTION.

181. *Loading, &c.*—At all stages of the work the material shall be handled with the greatest care to prevent any deformation, bend or twist of the members or any of their parts.

Cranes and special gripping apparatus for every piece, approved by the engineer, shall be provided for this purpose, as no skidding will be allowed. The engineer shall have the absolute right to stop and prevent any handling he may deem to be injurious to any part of the material and his orders shall be obeyed at once.

Material shall be loaded with the greatest care and to the satisfaction of the Engineer, so as to prevent injury in transit.

182. *Shipping suspenders.*—Suspenders shall be shipped with their shoes in place and firmly connected to them, be laid on the cars without bends and thoroughly protected from the weather. They shall be handled throughout with the greatest care.

183. *Weighing.*—The inspector shall be notified before the weighing of any material is done, and copy of the weights shall be immediately sent to the Engineer.

The materials may be weighed before or after painting, but no allowance for painting after weighing shall be made.

The weight of field rivets paid for shall be the weight of the rivets actually left in the bridge.

184. *Storing material.*—All material, both in the field and at the shops, must be so stored as to prevent injury to it, and to prevent, as far as possible, any accumulation of water or dirt on it.

Stringers and floorbeams must be stored on edge and not be laid on their sides.

185. *Inspection.*—When the material is unloaded it shall be reinspected before erection.

186. *Erection.*—Erection shall be proceeded with according to the approved programme.

All main members, between panel points, shall be completely riveted before another main panel is erected.

187. *Bolts and drifts.*—Two-thirds of the rivet holes in erection splices and connections shall be filled up with bolts and one-third with drift pins, equally distributed

throughout the joint. The diameter of erection bolts and drift pins, and the shape of drift pins must be approved by the Engineer. Before riveting, all bolts shall be screwed up as tight as possible. Not more than one-third of the holes not filled up with rivets shall at any time be without bolts properly distributed to ensure a thorough pinching of the materials.

188. *Mode of erection.*—The cantilevers may be erected either by first building the shore arm complete, or by starting on both sides of the main piers. In the latter case, a concrete pier shall be built at the first panel point from the main pier towards the anchorage, and the stability of the works under wind and temperature shall be secured by these two supports alone.

The cost of said concrete piers and concrete foundations under the false work shall be borne by the Contractor.

In any case the shoes shall first be put in place and securely bolted to the masonry and the erection of the bottom chord shall start from the shoes.

189. *Anchorage.*—All anchorage steel built in the piers shall be laid by the Contractor. It shall be manufactured, shipped and erected so as not to delay the Contractor for masonry.

190. *Reversed strains during erection.*—Whenever tension members have to temporarily carry compression during erection, they shall be so packed and stayed as to be able to safely carry said compression.

191. *Cantilevering out suspended span.*—In case the suspended span is erected by cantilevering out, its erection shall be started only after the Chief Engineer is satisfied that the final connection can surely be made before winter interrupts the work.

192. *Surveys and location.*—The Contractor shall make all necessary measurements to check the location of the masonry piers and abutments and a complete agreement as to these measurements must be arrived at between the Contractor and the Chief Engineer before erection begins. Any error between the plans and the masonry as built shall be corrected in the dimensions shown on the plans.

The Contractor shall also locate the shoes, anchorages and all other parts of the bridge and must come to a complete agreement on said location with the Chief Engineer.

And the Contractor shall be held entirely and completely responsible for any errors in the measurements and locations mentioned in this paragraph.

193. *Holes for stone bolts.*—Holes for stone bolts connecting the shoe to the pier shall be drilled in the masonry with the greatest care so as not so split the stone, as soon as all the shoes have been placed in their final positions.

194. *Filling with concrete.*—The interior of any part of the shoes shall be filled with cement concrete, and cement mortar and grout where and when ordered by the engineer.

195. *Open joints during erection.*—See paragraph 93.

196. *Web members in tension.*—All pins, of each panel, in web members made of several lengths of eyebars, shall be kept in straight line at all stages of erection.

197. *Workmanship.*—All other pertinent clauses of these specifications shall apply to erection.

198. *Maintenance of staging, false work, &c.*—The Contractor shall keep all staging and false work in a safe condition, and provide such temporary stairways, gangways, staging, rope railing, &c., as the Engineer may direct to allow a thorough inspection of the work during construction.

MATERIALS.

Rolled Carbon Steel.

199. *Furnace used.*—All structural steel shall be made in an open-hearth furnace.

200. *Decarburization.*—During the reduction of steel in the open-hearth furnace decarburization below 0.12 per cent of carbon will not be allowed.

201. *Phosphorus and sulphur in stock.*—No stock used in the open-hearth furnace shall contain more than .10 of one per cent of phosphorus or more than .07 of one per cent of sulphur.

202. *Iron ore.*—The use of iron ore for the reduction of carbon in the furnace charge will be permitted according to usual and good practice.

203. *Recarburization.*—The recarburization of steel and addition of manganese shall be performed in a careful manner, giving the most uniform results and to the satisfaction of the Engineer.

204. *Chemical requirements.*—The ladle tests of steel as usually taken shall not contain more than the following proportions of the elements named:

	Acid.	Basic.
Phosphorus	.06 per cent.	.04 per cent.
Sulphur	.04 "	.04 "
Manganese	.60 "	.60 "
Silicon	.10 "	.10 "

It is desired that the carbon contents be as small as possible to meet the specifications.

205. *Rivet steel.*—The ladle tests of the carbon rivet steel shall not contain more than .035 of one per cent of phosphorus, and not more than .03 of one per cent of sulphur.

206. *Ingots.*—The amount of discard from the top and bottom of ingots must be sufficient to insure steel of uniform quality, free from piping and undue segregation.

Slab ingots shall not be allowed.

207. *Finished product.*—The finished material shall be free from injurious seams, flaws, cracks or defective edges, and have a clean smooth finish.

It shall be true to section. The variation in weight shall be in accordance with the standard specifications of the American Society for testing materials.

208. *Physical requirements.*—Specimens cut from the finished material shall show the following physical properties:

Material.	Ult. Strength. (Lbs. per square inch.)	Minimum Yield Point. (Lbs. per square inch.)	Minimum Elongation. (Per cent. in 8 inches.)	Minimum Reduction. (Per cent of area.)
Shapes and plates	62,000 to 70,000	35,000	$\frac{1,500,000}{\text{ultimate.}}$	44 per cent.
Rivets	48,000 to 56,000	28,000	$\frac{1,500,000}{\text{ultimate.}}$	50 per cent.

Yield point to be determined by drop of the beam.

Speed of machine for testing samples to be such that material under tension will not elongate more than one inch in two minutes.

209. *Bending tests.*—Specimens cut from plates, bars and shapes two inches wide shall bend cold 180 degrees around a rod of a diameter equal to the thickness of the specimen; when at or above a red heat, 180 degrees flat.

Specimens cut from rivet rods shall bend 180 degrees flat when cold, or when at or above red heat. A test piece two inches long when heated to a bright cherry red shall flatten longitudinally under the hammer to a thickness of $\frac{1}{4}$ inch without cracking on the edges.

Full sized sections of eyebar material as rolled without annealing shall bend cold about a rod of diameter equal to twice the thickness of the bar.

All specimens in bending tests must show no signs of cracking on the outside of the bend.

210. *Fractures in tension.*—The fracture of all tension tests shall show a fine, silky texture, of a uniform bluish gray or dove colour, free from black or brilliant specks, and show no sign of crystallization.

ROLLED NICKEL STEEL.

211. *Furnace.*—All nickel steel shall be made in an open-hearth furnace. It shall be made in the same manner and of the same stock as specified for rolled carbon steel with the addition of nickel.

212. *Chemical requirements.*—The ladle test shall contain not less than 3.25 per cent of pure nickel, and not more than the following proportions of the elements named:

	Acid.	Basic.
Phosphorus	.06 per cent.	.04 per cent.
Sulphur	.04 "	.04 "
Manganese	.60 "	.60 "
Silicon	.10 "	.10 "

213. *Heating and rolling.*—Care shall be taken in the heating and rolling of nickel steel to prevent the formation of heavy scale. The material must not be pitted by rolling the scale into it. All material with pitted or heavily scaled surfaces, or with ragged edges, will be rejected.

214. *Physical requirements.*—Nickel steel for plates and shapes in the finished material must meet the following physical requirements:

Ultimate strength, 83,000 to 95,000 lbs. per sq. in.
Yield point, 55,000 lbs. per sq. in. minimum.

Elongation in 8 inches (per cent.), $\frac{1{,}600{,}000}{\text{ultimate}}$ minimum.

Reduction of area, 40 per cent. minimum.

Nickel steel for pins in the finished material must meet the following physical requirements:

Ultimate strength, 90,000 to 100,000 lbs. per sq. in.
Yield point, 55,000 lbs. per sq. in. minimum.

Elongation in 8 inches (per cent.), $\frac{1{,}500{,}000}{\text{ultimate}}$ minimum.

Reduction of area, 35 per cent. minimum.

STEEL CASTINGS.

216. *Furnace.*—Steel for castings shall be made in an open-hearth furnace.

217. *Stock.*—At least one-third of all stock used for steel castings shall be pig-iron; and, when scrap is used it shall be of a kind and quality satisfactory to the Engineer.

218. *Decarburization.*—During the reduction of the steel in the furnace, it shall not be decarburized below .10 of one per cent.

219. *Use of iron ore, &c.*—In making steel for castings, the use of iron ore, ferro silicon, ferro-manganese and spiegeleisen will be allowed according to usual and good practice.

220. *Chemical requirements.*—The ladle test of steel for castings shall not contain more than the following proportions of the elements named:

Phosphorus	.04	of one per cent. for basic steel.
Phosphorus	.06	of one per cent. for acid steel.
Sulphur	.05	" " "
Manganese	.75	" " "
Silicon	.35	" " "

221. *Annealing.*—All steel castings shall be carefully and thoroughly annealed in a manner approved by the Engineer, and shall have a fine grained or silky fracture.

222. *Soundness of castings.*—All castings shall be sound and free from shrinkage cracks and as free from sand holes and blow holes as the latest and best practice can produce. The Engineer shall be the final judge as to whether a defect is sufficient cause for rejection. Every casting which contains a blow hole or blow holes, or any other cavity or flaw of such size so placed as to injure it materially, shall be rejected.

223. *Welding of castings.*—No electric or other welding or patching of defects in castings shall be done, unless authorized by the Engineer. Any such welding or patching done without the Engineer's consent shall cause the rejection of the casting.

224. *Physical tests.*—Test pieces taken from coupons on the annealed castings shall show an ultimate strength of not less than 65,000 lbs. per square inch, an elastic

limit of at least 35,000 pounds per square inch, and an elongation of not less than 20 per cent. in two inches. They shall bend without cracking 120 degrees around a rod twice the thickness of the test piece.

225. *Shape and finish.*—All steel castings must be true to the drawings, with smooth surfaces, and all re-entrant angles must be neatly filleted. They must be planed exactly true and smooth where the drawings require, and all holes for bolts must be drilled accurately to metal templets. Bolt holes in castings shall be 'spot-faced' wherever required by the Engineer.

226. *Cleaning.*—All cores of castings shall be thoroughly removed and the mould sand thoroughly cleaned from the surfaces.

CABLES, SUSPENDERS AND HAND ROPES.

227. *Steel for wire.*—All steel for wire for the cables, suspenders and hand ropes shall be made throughout in an open-hearth furnace, lined with silica.

The wire for serving the cables shall be made of Norway iron of a quality approved by the Engineer.

228. *Stock.*—The melting stock used for wire steel shall consist of pig iron to the extent of not less than 45% of the total charge, together with other suitable melting stock. None of the pig iron and none of the other melting stock shall contain more than .03 of one per cent of phosphorus or .03 of one per cent of sulphur.

229. *Reduction of carbon.*—The use of iron ore for the reduction of carbon in the furnace charge will be allowed according to the usual and good practice.

230. *Recarburization.*—The recarburization of steel is essential and the addition of manganese and carbon shall be accomplished by the use of ferro-manganese or spiegeleisen only, and shall be performed carefully, in a manner most likely, in the opinion of the Engineer, to give good results.

231. *Decarburization.*—During the reduction of the steel in the open-hearth furnace, it shall not be decarburized below .20 of one per cent.

232. *Chemical requirements.*—The ladle tests of the steel shall conform to the following chemical requirements:

Carbon, not to exceed	.85	of one per cent.
Manganese, not to exceed	.55	"
Silicon, not to exceed	.20	"
Phosphorus, not to exceed	.04	"
Sulphur, not to exceed	.035	"
Copper, not to exceed	.02	"

233. *Ingots.*—The finished steel shall be cast in ingots of such size, weight and shape and so poured as, in the judgment of the Engineer, to eliminate to the greatest degree piping and harmful segregation. All surface defects shall be removed, and enough of the top of each ingot discarded to insure sound material. This discard must represent not less than 30 per cent of the weight of the ingot, and shall extend as much farther as may be necessary to secure freedom from pipings and injurious segregation.

234. *Billets.*—The wire billets rolled from these ingots shall be free from cracks and seams, and shall be straight and have square sections, suitable for rolling into

wire rods. The billets shall be cut into uniform lengths, to weigh not less than 350 pounds each, and surface defects shall be cut out.

235. *Physical requirements.*—The wire for cables, hand ropes and suspenders shall have an ultimate strength of not less than 215,000 pounds per square inch before galvanizing, and an elongation of not less than two per cent in twelve inches of observed length, the stretch to be measured while the specimen is in the testing machine. The bright wire shall be capable of coiling cold around a rod of $1\frac{1}{2}$ times its own diameter without sign of fracture. The cable wire before galvanizing shall not vary in gauge more than 3-1000 of an inch. It shall be drawn on large-sized blocks, and finished in single lengths of not less than 3,000 feet, and shall be drawn as straight as possible without any kinks or sharp bends. After galvanizing, the steel wire shall have an ultimate strength of not less than 200,000 pounds per square inch of gross section.

236. *Wire straightening.*—No machine straightening of wire shall be allowed. The wire must not, from tendency to coil, cause trouble or delay during any of the operations, from the splicing and winding on reels, to the completion of stringing into cable strands.

237. *Cable shield.*—While reeling the wires on large reels after galvanizing and splicing, the wires shall be run through a bath of cable shield so that they will be thoroughly coated therewith.

238. *Number of tests of wire.*—Sufficient physical tests on the finished coils of wire shall be made at the mills to satisfy the Engineer that the wire meets the specified requirements; but tests may be taken from both ends of each coil, in order to insure the specified physical requirements. Tests on pieces of wire not less than twelve feet long shall also be made.

239. *Field splices.*—All field splicing of wire shall be done with thread cutting dies of approved pattern and in first-class condition, and shall be done by skilled workmen.

240. *Strength of wire for ropes.*—The wire for the cables, cable serving, hand ropes and suspenders shall be galvanized and inspected as to the following requirements for galvanided wire: When galvanized, it shall gauge not more than 5-1000 of an inch larger than the bright wire. The galvanized wire shall have an elongation of 4 per cent in twelve inches of length, as observed under tension, and shall bend continuously around a mandrel four (4) times the diameter of the wire without breaking or peeling off any of the zinc coating.

241. *Zinc for galvanizing.*—The galvanizing shall consist of a coat of zinc 99.75 per cent pure containing not more than .03 of one per cent. of iron. It shall be applied in the molten state in an even and uniform manner.

The zinc coating shall be so applied that it will adhere firmly to the surface of the wire and form a continuous coating of uniform thickness.

242. *Test for galvanizing.*—All specimens of galvanized wire shall be capable of withstanding the following test:

The sample shall be immersed in a standard solution of copper sulphate for one minute, immediately washed in water thoroughly and wiped dry. This process shall be repeated. If, after the fourth immersion there should be a copper-coloured deposit on the sample, or the zinc should have been removed, the sample shall be rejected.

243. *Solution for test.*..—The standard solution of copper sulphate shall consist of a solution of commercial copper sulphate crystals in water. This solution shall

have a specific gravity of 1.185 at seventy (70°) Fahrenheit. While a sample is being tested, the temperature of the standard solution shall at no time be less than sixty (60°) degrees Fahrenheit, nor more than sixty-five (65°) degrees Fahrenheit. While galvanizing the cable wire shall be coiled on blocks not less than four (4) feet in diameter.

GENERAL PROVISIONS AS TO STEEL.

244. *Manufacturers of steel.*—All steel for any purpose in this bridge shall be made by manufacturers of established reputation for the kind and character of steel specified.

245. *Size of billets.*—All finished material shall be rolled or forged from billets which are of a size to reduce at least sixteen times in area in forming the finished shapes.

246. *Treatment of furnace charge.*—No lime or other basic material other than iron ore shall be added to the furnace charge of acid open-hearth steel during any stage of the melting or pouring of the steel.

247. *Acceptance not final.*—Acceptance of any material at the mill, foundry or elsewhere, before acceptance of the bridge by the Minister, will not be considered as final.

248. *Identification.*—No steel will be accepted unless made especially for this work; and when so made, it shall be subject to a system of identification approved by the Engineer, and, furthermore, such especially made steel shall be handled by itself or isolated in any manner required by the Engineer, to prevent the possibility of its becoming mixed with other kinds of steel.

249. *Presence of inspector.*—No steel shall be made or cast, nor shall any material be rolled unless the Engineer or inspector has been notified in time to be present.

250. *Orders to manufacturers direct.*—All orders for steel shall be placed by the Contractor directly with the manufacturer, and all such orders shall have embodied in them the full specified requirements for the same, and as many carbon or hektograph copies of all orders for steel shall be furnished to the Engineer, at the time of placing such orders with the manufacturer, as he may require.

INSPECTION AND TESTING.

251. *Inspectors.*—The mill inspection shall be made by the Contractor at his own expense.

The inspectors appointed by the Contractor must be accepted by the Chief Engineer and must be men well trained in the business, independent of the manufacturer of steel, and in sufficient numbers to give thorough inspection according to these specifications

252. *Representative of the Chief Engineer.*—The Chief Engineer, at the expense of the Minister, may appoint a representative whose duty it will be to see that the inspection is satisfactorily performed.

253. *Chemist.*—The Chief Engineer, at the expense of the Minister, may appoint a chemist who will check tests made by the Contractor, said chemist to be provided by the Contractor with all office, apparatus and chemicals necessary to perform said tests.

254. *Weekly reports.*—Weekly reports in full detail, including reports of chemical analysis shall be sent to the Chief Engineer, not later than the end of the week succeeding the week in which such tests were made.

255. *Results of tests.*—The results of physical tests must be given in pounds per square inch.

256. *Inspection.*—All stock and materials used in the manufacture of the steel and all operations at the furnaces, rolls and elsewhere about the establishments where the steel is made or manufactured, shall be subjected to the examination, approval and acceptance of the inspector, who shall have free access to all records appertaining to the manufacture of the steel, from the beginning until its final acceptance. Ingots, &c., shall be so marked that the steel and heats can be identified at any time during the process of manufacture. The marks must be stamped on the hot material.

257. *Chemical analysis, how made.*—Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese (and nickel in the case of nickel steel) shall be made by the manufacturer, from one or more test ingots taken during the casting of each melt of steel, said test or tests to be fairly representative of each melt of steel. Two correct copies of such analysis shall be furnished to the inspector. Check analyses shall be made of the finished product on drillings from the tensile or bending test pieces of the rolled or forged material, and taken as directed by the Chief Engineer or chemist appointed by him.

258. *Test pieces, plates, shapes and bars.*—Specimens for determining the tensile strength, elastic limit, per cent of elongation and per cent of reduction, of plates, shapes and bars, shall be taken from the rolled material, without annealing, unless the material itself is annealed, and specimens for bending shall be taken in the same way.

259. *Copies of records.*—The Contractor shall furnish to the inspector copies of all records and furnish all facilities necessary to enable him to readily keep track of the steel and identify any heat at any stage during the process of manufacture. Two pieces of all mill orders shall be furnished to the inspector besides the copy sent to the Engineer.

260. *Ultimate strength required.*—There shall be at least three tensile tests and two bending tests from each melt of steel.

In case the ultimate strength falls outside of the specified limits by less than one thousand (1,000) pounds, all other requirements being filled, or in case the elastic limit falls below the specified minimum by less than 1,000 lbs. all other requirements being filled, then two more tests may be taken from material of same thickness for each test thus failing, and if both such re-tests fill the requirements, the material will be accepted.

261. *Number of tests.*—If the material rolled from a melt varies in thickness by $\frac{3}{8}$ inch or more for plates and shapes, or by $\frac{1}{2}$ inch or more for bars, a test shall be made from the thickest, and also from the thinnest material rolled from the melt.

Separate tests shall be made for (1st) plates, (2nd) shapes, and (3rd) bars.

262. *Check analysis.*—Check analyses of the finished steel or wire billets may be made at any time when required by the Engineer. These check analyses shall not show a variation of more than 25 per cent above the ladle analysis for phopshorus or more than 50 per cent above the ladle analysis for sulphur. These check analyses are to be taken from the parts suspected of being most highly segregated.

263. *Additional tests.*—Additional tests shall be made if the melt is rolled at different places.

264. *Number of tests from steel castings.*—The number of coupons required on steel castings will depend upon the size and importance of the castings. They must be of such number as will insure uniformity as well as quality of the castings, and their number and location shall be determined by the inspector. Coupons must not be detached from castings until after they are annealed.

265. *Forms of test pieces.*—Test pieces will generally be of the form recommended by the American Society for Testing Materials.

266. *Contractor to furnish test pieces.*—The Contractor shall at his own expense furnish all test pieces of such shape and perform such tests thereon under the supervision of the inspector as required by the Engineer.

267. *Rivet rods.*—Specimens of rivet rods shall be cut from the finished rods without further preparation.

268. *Pins.*—Test specimens shall be cut at a depth from the cylindrical surface equal to one-half the radius of the pin. All forged pins shall be annealed. Pins shall be tested individually (tensile test), but may be forged or rolled, as the case may be, in multiples, in which case two tensile tests shall be taken. one from each end of the bar. Each pin shall be so marked as to be easily identified. Tensile tests may be the usual 8-inch specimens, or may be two inches (2″) between measuring points and $\frac{1}{2}$ inch diameter, in which case the minimum elongation in two inches shall be $\frac{1{,}800{,}000}{\text{ultimate strength}}$

269. *Office room for inspectors.*—The Contractor shall furnish for the use of the inspector a suitably equipped office at the mills and at the shops.

270. *Facilities for inspection.*—The inspector shall be on hand to make all examinations and tests promptly. All facilities necessary must be furnished by the Contractor to the inspector to make these examinations and tests thorough and conclusive.

No material shall be inspected on the hot beds or at night, or outside in bad weather, or in dark places and the Contractor shall furnish all men and appliances necessary to handle and turn over all materials, to allow of a thorough inspection being made.

271. *Rejection.*—Any piece of material which, through oversight or otherwise has passed the inspector, may be rejected at any stage of the work, if found defective or contrary to these specifications.

272. *Stamping melt number.*—Every plate or shape shall be distinctly stamped near the middle with the melt number, which shall be surrounded with a heavy circle of white paint. Pin steel shall be stamped on ends. Rivet steel may be shipped wired in bundles with the melt number attached.

FULL SIZE TESTS.

273. *Tests required.*—The manufacturer shall at his own expense furnish, build and test the following number of samples of wire suspenders, full size eyebars, and tension and compression members.

274. *Wire suspenders.*—Two suspenders shall be tested, similar in every respect to the suspenders used, except that they shall be made of the maximum length that the longest existing testing machine will admit.

Their stretch shall be measured under increments of load of 10,000 lbs. until destruction.

The strands, as well as the shoes, shall stand, without breaking, a load of 150,000 lbs. per square inch of wire in the strands.

These tests shall be made before the suspenders used in the bridge are manufactured; and if the final strength of 150,000 lbs. per square inch is not obtained in the shoes or strands, the manufacturer shall, at his own expense, furnish, build and test other samples until two consecutive tests show the required strength.

275. *Eyebars.*—Tests of full size eyebars shall be made as follows:

From every lot of forty (40) eyebars, not rejected for surface defects, one bar shall be selected by the inspector. All bars of each lot must have had as far as possible the same treatment and have been finished at about the same time.

Each lot must be kept separate and distinct until the full size tests representing them have been made and the bars accepted.

The bars will be required to meet the specifications and to break in the body. In the event of failure to do so two additional bars shall be selected by the Engineer and tested. If either one of these bars fails to meet the specifications or breaks in the head, the entire lot of bars shall be rejected.

Full size tests of nickel steel eyebars, after annealing, must meet the following requirements:

Yield point (minimum), 47,000 lbs. per sq. in.

Ultimate strength, 75,000 to 90,000 lbs. per sq. in.

Elongation in 18 feet (minimum), 10%.

Reduction of area (minimum), 35%.

Full size tests of carbon steel eyebars, after annealing, must meet the following requirements:

Minimum ultimate strength, 58,000 lbs.

" elastic limit, 30,000 lbs.

" elongation, 10 per cent.

276. *Tests of riveted tension members in case the contract is awarded on the Board's plans.*—The Contractor shall, at his own expense, as soon as the contract has been awarded, furnish, build and test two models of each main built tension diagonal and chord of the cantilever and shore arms. (Six (6) tests altogether).

Such pieces to be of the maximum reduced section and maximum length that the largest testing machine available will break, and designed so that the pin plates, splices and body be thoroughly tested.

One leaf shall represent the member.

In case the tests are unsatisfactory the design shall be altered and new tests made at the expense of the Minister, until satisfactory results are obtained.

277. *Tests of riveted tension members in case the contract is awarded on Contractor's design.*—In case the contract is awarded on the Contractor's design, two test models of each main built tension diagonal and of each main built tension chord panel of the cantilever and shore arms shall be tested. The same specifications for tests as in the case of acceptance of Board's plans of built up tension members shall govern, but all tests shall be made at the Contractor's expense.

Tension tests of nickel steel riveted tension members must meet the following requirements:

Yield point (minimum) 55,000 lbs. per sq. in. (net section).
Ultimate strength (minimum) 75,000 lbs. per sq. in. (net section).

278. *Compression members.*—The board has made tests of nickel steel compression members representing the types of sections used in the plans exhibited. Full information about these tests can be obtained from the Chief Engineer. In case the contractor wishes to use carbon steel members of similar section or to use different sections from the ones shown, he shall, at his own expense, furnish, build and test specimens representing these sections; such specimens to be of the same number, and as nearly as possible of the same length, area and quality of material as those made by the Board.

In case the specimens of nickel steel tested do not come up to the results obtained by the Board, or in case the specimens made of carbon steel of quality specified do not come within 20% of the result obtained by the Board for nickel steel members, new sections shall be designed and tested, at the Contractor's own expense, until the required strength is obtained. In any case specimens to be tested shall be made of the same material as the members they represent.

279. *Use of testing machines.*—The Contractor shall furnish free of charge to the Minister, the use of testing machines for all tests. Eyebars and built members shall be tested in the strongest machine available.

PAINTING.

280. *Paint.*—The paint shall be made of pigment, thoroughly mixed in boiled linseed oil, without spirits of turpentine.

281. *Dryer.*—Dryer shall be made of linseed oil, boiled with lead or manganese, dissolved in spirits of turpentine.

282. *Use of dryer.*—No dryer will be added to the paint unless authorized by the Engineer, and the quantity of dryer to be added in every particular case shall be given by the Engineer in writing, but shall in no case be more than three per cent. (3%), with the exception of the paint used on materials before riveting, where the Engineer may allow a larger percentage to be used.

The permission to use dryer must be obtained from the Engineer three or four days in advance in order to allow him to have the necessary tests made to determine the time required for drying; one without dryer, one with 1½%, and one with 3% dryer added.

283. *Oil.*—The oil shall be pure and clear linseed oil, boiled with lead or manganese to a minimum specific gravity of 0.939.

The boiled linseed oil must be absolutely pure, containing no material volatile at 212 degrees Fahrenheit in a current of hydrogen; shall not contain any rosin or manganese or rosinate of manganese, and shall be perfectly clear on receipt, and no deposit should form on standing, provided the oil is kept at a temperature above 45 degrees Fahrenheit. The film left after flowing the oil over glass and allowing it to drain in a vertical position must dry to the touch after 24 hours.

284. *Delivery of oil.*—The linseed oil shall be delivered in strong, tight, well made white oak casks, hooped with iron, each having a capacity not exceeding 50 gallons.

285. *Pigment.*—The pigment shall be pure red lead with addition of lamp black not to exceed four (4) ounces of lamp black to thirty (30) pounds of red lead for the shop paint.

Peroxide of iron shall be used for the paint before riveting. The pigment and colour to be used after erection shall be determined later by the Minister.

286. *Red lead.*—The red lead must be strictly pure, and shall contain at least 90 per cent. of true red lead (of the composition Pb. 3.04) the total amount of lead present shall not be less than 89 per cent, of which not more than 1-10th of one per cent, shall be present as metallic lead. The colour shall be a clean and pure tint. The red lead shall be of the fineness that when washed with water through No. 19 silk bolting cloth not more than one per cent shall be left on the screen.

287. *Delivery of red lead.*—The red lead shall be delivered in suitable 100 pounds packages.

288. *Paint to be kept in original packages.*—All paint material to be delivered, inspected and sampled in the original packages.

289. *Inspection.*—Before acceptance the above specified materials shall be inspected; samples of each lot delivered will be taken at random, the samples well mixed together in a clean vessel, and the samples for test taken from this mixture; if it is found that this sample does not conform to the requirements of the specifications, the whole delivery it represents will be rejected, and shall be removed by the Contractor at his own expense.

290. *Chemist.*—Check tests of all paint materials shall be made by a Chemist appointed by the Chief Engineer and paid by the Minister. The Chemist shall be provided by the Contractor with an office, and all apparatus and chemicals necessary to perform said tests.

291. *Storage of paints and oils.*—The oils, paints, pigment, &c., used in connection with this contract must be kept at the shops in a storage room separate from that in which any other paints are kept.

292. *Material not to be exposed to weather.*—All rolled metal work shall be kept under cover as far as practicable from the time it is rolled until it is painted, and no material which has been punched or planed shall thereafter be exposed to the weather until it has been painted.

All material arriving from the mills shall be unloaded without delay, and protected from rust by being stored under cover or by the application of a coat of pure boiled linseed oil.

293. *Cleaning.*—Before painting at the shop, all material shall be thoroughly cleaned of scale, rust, grease, dirt, chips and borings with steel scrapers and brushes or by any other efficient method. Benzine shall also be used wherever required by the inspector for this purpose.

294. *Painting.*—The paint shall contain as much pigment as possible, be kept well mixed before and during painting and applied with brushes, and be well worked into all joints and surfaces. Wherever the paint runs or streaks a fresh coat shall be applied.

295. *Number of coats.*—In riveted work, the surfaces coming in contact shall each be painted before being bolted together, and the paint must be dry before assembling.

After the pieces are finished in the shop, they shall be given one good coat of paint.

Pieces and parts which are not accessible for painting after erection, including tops of stringers, eyebar heads, ends of posts and chords, etc., shall be given two coats of paint before leaving the shop and one extra coat before being erected in place.

The cable shield shall be thoroughly removed from the surface of the wire suspenders, which shall then be given two coats of red lead.

Machine finished surfaces, except faced ends of members, which shall be painted, shall be coated with white lead and tallow before leaving the shops.

All the painting before shipment specified above shall be done under cover and with metal dry and free from frost. The pieces must remain under cover until the paint is perfectly dry.

The heads of all field rivets shall be given a coat of red lead within three days after they are driven.

After the steel is erected it shall be thoroughly cleaned and any parts where the paint has been scratched off or removed, shall be painted with red lead. The whole work shall then be given two additional coats as determined later by the Minister.

Painting shall be done only in dry weather and applied only on surfaces dry and free from frost.

CONCRETE AND ASPHALT IN HIGHWAY FLOOR.

296. *Concrete in roadway.*—The concrete shall be composed of one part of cement, two parts of sand and five parts of granite of such size as to pass through a $\frac{3}{4}$ in. ring.

297. *Sidewalks.*—Sidewalks shall be made of slabs of reinforced concrete, with one-half inch wearing surface of concrete. The concrete shall be composed of one part of cement, two parts of sand and two parts of granite of such a size as to pass through a $\frac{1}{2}$ inch ring for the slabs and $\frac{1}{4}$ inch for the wearing surface. The concrete shall be kept wet and under cover for thirty days. A small quantity of lamp black may be added as directed by the Engineer.

298. *Cement.*—The cement shall be of the quality specified in the 'Specifications for Foundations and Masonry.'

299. *Asphalt and granite curb stones.*—The asphalt coating and granite curb stones shall be in all respects equal to the asphalt and curb stones laid by the City of Quebec and in accordance with specifications proposed by the Contractor, subject to the acceptance of the Chief Engineer. Gutters shall be provided as per plans to be furnished later on.

H. E. VAUTELET,
Chief Engineer.

MONTREAL, June 1st, 1910.

LIST OF DRAWINGS EXHIBITED.

Drawing S1 Strain sheet for anchor arm.
" S2 Strain sheet for cantilever arm.
" S3 Strain sheet for suspended span.
" S7 { I. Uniform dead loads. II. All other dead loads. III. Live loads.
" S8 Loading for maximum live load strains.
" S9 Total wind, temperature and traction strains.
" S10 Strains from wind pressure on bridge.
" S11 Strains from wind pressure on train.
" S12 Wind strains during erection.

Drawing S13 Axial wind strains.
" S14 Strain sheet for temperature and traction.
" S15 Erection strains.
" S16 Primary and secondary bending strains, anchor arm.
" S17 Primary and secondary bending strains, cantilever arm.
" S18 Primary and secondary bending strains, suspended span.
" S19 Data for secondary strains.
" W1 Williot's diagram for calculating bending strains in posts from floor.
" W2 Williot's anchor arm deformation diagram; anchor arm loaded 6,100 lbs. per ft. L.L. per truss.
" W3 Williot's anchor arm deformation; diagram channel span loaded 6,100 lbs. per ft. L.L. per truss.
" W4 Williot's cantilever arm deformation diagram; channel span loaded 6,100 lbs. per ft. L.L. per truss.
" W5 Williot's cantilever arm deformation diagram; anchor arm loaded 6,100 lbs. per L.L. per truss.
" W6 Williot's anchor arm deformation diagram; dead load reversed.
" W7 Williot's cantilever arm deformation diagram; dead load reversed.
" W8 Williot's deformation diagrams for truss under erection loads.
" W9 Williot's deformation diagrams for suspended span; dead and live loads.
" W10 Williot's deformation diagrams, cantilever arm, bottom laterals.
" 1a General diagram, suspended span floated in.
" 1 General diagram, suspended span cantilevered out.
" 2 General floor plan.
" 3 Elevation panels A0-A2, anchor arm.
" 4 " " A2-A6 "
" 5 " " A6-A10 "
" 6 " " A10-A14 "
" 7 " " C14-C10 cantilever arm.
" 8 " " C10-C6 " "
" 9 " " C6-C2 " "
" 10 " " C2-C0 " "
" 11 " " S0-S7, suspended span.
" 12 Bottom laterals, panels, AL0-AL7, anchor arm.
" 13 " " " AL7-AL-14 " "
" 14 " " " CL14-CL7, cantilever arm.
" 15 " " " CL7-CL0 " "
" 16 " " " SL0-SL7, suspended span.
" 17 Top laterals, panels AU0-AU7, anchor arm.
" 18 " " AU7-AU14 " "
" 19 " " CU14CU7, cantilever arm.
" 20 " " CU7-CU0 " "
" 21 " " SU0-SU7, suspended span.
" 22 Portal and sway bracing AU0-AL0 and AU0-AL2, anchor arm.
" 23 Sway bracing AU4-AL6 and AU8-AL10, anchor arm.
" 24 " AU12-AL14 and CL14-CU12, anchor and cantilever arms.
" 25 Sway bracing CL10-CU8 and CL6-CU4, cantilever arm.
" 26 " CL2-CU0, cantilever arm.
" 27 " SL0-SU2, and SL4-SU6, suspended span.
" 28 " AL2-AU2 and AL6-AU6, anchor arm.
" 29 " AL10-AU10 and CL10-CU10, anchor and cantilever arms.

Drawing 30 Sway bracing CL8-CU6 and CL2-CU2, cantilever arm.
" 31 " AM3-AU3; AM7-AU7; CM7-CU7; CM2-CU3, anchor and cantilever arms.
" 32 Sway bracing AM11-AU12; CU12-CM11, anchor and cantilever arms.
" 33 Transverse sections SM3-SU3; SM4-SU4, SM7-SU7, suspended span.
" 34 Anchor arm wind bracing AL4-AF4; AL8-AF8; AL12-AF12, anchor arm.
" 35 Cantilever arm wind bracing L14-F14; CL12-CF12; CL8-CF8; CL4-CF4, cantilever arm.
" 36 Floorbeams.
" 37 Floorbeams and stringers.
" 38 Stringers and floor bracing.
" 39 Shoe.
" 40 Top chord packing.
" 41 Eyebar anchorage.
" 42 Elevation anchor arm.
" 43 Elevation cantilever arm and suspended span.
" D1 Detail drawing typical floorbeams, anchor and cantilever arms.
" D2 " " " suspended span.
Drawing M1 Cross section of river showing location of masonry.
" M2 Cross section showing borings taken on south shore and east of centre line of bridge.
" M3 Cross section showing borings taken on south shore and west of centre line of bridge.
" M4 Cross section showing boring on north shore and east of centre line of bridge.
" M5 Cross section showing borings taken on North shore and west of centre line of bridge.
" M6A Details of south main pier.
" M7 Details of north main pier.
" M8 Details of south anchor pier.
" M9 Details of north anchor pier.
" M10 Details of north intermediate pier.
" M11 Details of south abutment.
" M12 Details of north abutment.
" M13 Location of anchor bolts in main piers.
" M14 Location of north and south main piers in relation to old piers.

CONTRACT

THIS INDENTURE made the day of one thousand nine hundred and ten.

BETWEEN:—

and

HIS MAJESTY THE KING, represented herein by the Minister of Railways and Canals of Canada, of the Second Part:

WHEREAS the party of the First Part, for the consideration hereinafter mentioned, has agreed with the party of the Second Part to do, furnish and perform the works, materials, matters and things required to be done, furnished and performed, in the manner hereinafter described, in connection with the following work, or works, namely:

The supplying, making, building and erecting of the Superstructure of a railway and highway bridge over the St. Lawrence river near Quebec, the whole complete and ready for traffic as herein otherwise specified.

NOW THIS INDENTURE WITNESSETH that the said parties hereto hereby covenant, promise and agree, each with the other, as follows:—

1.—In this contract and in the specifications the following words shall, unless the context requires a different meaning, have the following meanings respectively, that is to say:—

"Contractor", or other words relative thereto, or of like import, shall mean and include, irrespective of sex or number, the party or parties of the first part as above designated or described, jointly and severally, and their and each of their executors, administrators, curators or successors, or assigns (duly consented to under this contract).

"His Majesty", or other words relative thereto, or of like import, shall mean and include the reigning Sovereign or the successors or assigns of the Sovereign.

"Minister", shall mean the person holding the position, or acting in the capacity of the Minister of Railways and Canals, for the time being.

"Board", shall mean the Board of Engineers for the time being appointed by the Governor General in Council to superintend the construction of the works. The Board shall act through its chairman.

"Chief Engineer", shall mean such person or persons as the Governor in Council shall from time to time appoint to act as Chief Engineer of the works.

"Engineer", shall mean the Chief Engineer as above described, acting either directly or through any duly authorized officer or agent of His Majesty, such officer or agent acting within the scope of the particular duties entrusted to him: Provided that every order, direction, certificate, instruction or decision given or made by any such officer or agent shall be subject to the approval of such Chief Engineer, and may be cancelled, altered or otherwise modified by such Chief Engineer as he sees fit.

'Work or works', shall mean the whole of the work and materials, matters and things required to be done, furnished and performed by the Contractor, under this contract.

2. All the covenants and agreements in this contract binding on, and all the provisions in this contract inuring to the benefit of the Contractor shall, respectively, be binding on, and inure to the benefit of the executors, administrators, curators, successors and assigns (duly assented to under this contract) of the Contractor; and all the covenants and agreements in this contract, binding upon, and all the provisions in this contract inuring to the benefit of, His Majesty, shall, respectively be binding upon and inure to the benefit of the successors and assigns of His Majesty.

3. The Contractor shall, at his own expense (except as in this contract otherwise specifically provided), provide all and every kind of labour, superintendence, services, tools, implements, machinery, plant, materials, articles and things necessary for the due execution, erection and completion of the superstructure of a railway and highway bridge over the St. Lawrence River near Quebec and as the work is more particularly set out or referred to in the specifications hereto annexed, in any supplementary specifications referred to therein, and in the plans and drawings prepared and to be prepared for the purposes of the work, and shall forthwith commence the work and diligently execute and fully complete the respective portions thereof, and shall deliver the work complete in every particular to His Majesty on or before the day of A. D., one thousand nine hundred and and time shall be deemed to be material and of the essence of this contract: Provided, however, that the Minister may for any reasons that appear satisfactory to him grant such extension or extensions of the time for the completion of the works as he may think proper; and time shall be deemed to be material and of the essence of any such extensions.

4. The work shall be constructed by the Contractor and under his personal supervision of the best materials of their several kinds, and finished in the best and most workmanlike manner, and in the manner required by and in strict conformity with this contract, the said specifications and any supplementary specifications, and the plans and drawings and the working or detail drawings which may from time to time be furnished (which said specifications and supplementary specifications, plans and drawings are hereby declared to be part of this contract), and to the complete satisfaction of the Chief Engineer.

5. The work shall be commenced, carried on and prosecuted to completion by the Contractor in all its several parts in such manner and at such points and places as the Chief Engineer shall, from time to time, direct, and to his satisfaction, but always according to the provisions of this contract, and if no direction is given by the Chief Engineer then in a careful, prompt and workmanlike manner. The erection of the bridge shall be commenced on each side of the river as soon as possible and shall thereafter be carried on concurrently on both sides of the river. All false works, erection plant and machinery shall be provided in duplicate by the Contractor.

6. The several parts of this contract and of the specifications, supplementary specifications, plans and drawings, shall be taken together, to explain each other and to make the whole consistent; and if it be found that anything has been omitted or mis-stated which is necessary for the proper performance or completion of any part of the work, the Contractor shall, at his own expense, execute the same as though it has been inserted and properly described, and the correction of any such omission or error shall not be deemed to be an addition or deviation from the work hereby contracted for.

In the event of any inconsistency between this contract and the provisions of the specifications or supplementary specifications, the provisions of this contract shall prevail.

7. If any change or deviation in or omission from the works be made by which the amount of work to be done shall be decreased, or if the whole or any portion of

the works be dispensed with, no compensation shall be claimable by the Contractor for any loss of anticipated profits in respect thereof, nor shall any such change, deviation or omission affect or change the price units upon which the Contractor is to be paid.

8. The Chief Engineer shall be the sole judge of the work and material in respect of both quality and quantity, and his decision on all questions in dispute with regard thereto, or as to the meaning or intention of this contract and as to the meaning or interpretation of the plans, drawings, calculations, specifications and supplementary specifications, shall be final, and no work under this contract shall be deemed to have been performed, nor materials or things provided, so as to entitle the Contractor to payment therefor unless and until the Chief Engineer is satisfied therewith, as evidenced by his certificate in writing, which certificate shall be a condition precedent to the right of the Contractor to be paid therefor.

9. The Contractor shall, in all things, conform to and comply with the instructions of the Engineer and all orders, directions or instructions at any time given by the Engineer with respect to the work or concerning the conduct thereof shall be promptly and efficiently obeyed, performed and complied with to the satisfaction of the Engineer. And the Engineer shall have the right to stop erection on any part of the bridge or to stop work altogether and any such orders shall be at once obeyed by the Contractor.

10. No verbal notice, order, direction or communication given to the Contractor, his engineers, officers, servants or employees whether the same be given by the Minister, the Board, the Chief Engineer or the Engineer, shall be binding on His Majesty, but all such notices, orders, directions or communications to be of any force or effect must be given in writing.

11. Whenever the Contractor is not present on any part of the work where it may be necessary to give directions, orders may be given by the Engineer, and such orders shall be received and obeyed by the Engineer, Superintendent or overseer of the Contractor who may have charge of the particular work in relation to which the orders are given and such orders shall be considered as given to the Contractor.

12. Any notice, order, direction or other communication given to the Contractor under the provisions of this contract shall be sufficiently given if delivered to the Contractor personally, or to his foreman, or left at the Contractor's office, or mailed at any post office to the Contractor or foreman addressed to the address mentioned in this contract, or to the Contractor's last known place of business or residence. Every such notice, order, direction or communication, shall be sufficient which expresses in general language and without detail, the matters required or communicated, or which follows the general language of the section or sections of this contract under which it is given, and no objection shall be taken to the form thereof.

13. All work or material which, in the opinion of the Engineer is imperfect or insufficient shall be remedied when pointed out, and shall be made good and sufficient by the Contractor at his own expense and to the satisfaction of the Engineer, who shall have the power, and whose duty it shall be, to have any defective work or material taken out and rebuilt or replaced at the expense of the Contractor. Any omission by the Engineer to disapprove of or reject any insufficient or imperfect work or material at the time of any estimate, shall not be deemed an acceptance of such work or material.

14. All material, false works, machinery, plant, buildings and their contents, equipment, articles and things whatsoever, needed for the construction of the work

and provided by the Contractor and erected or deposited by the Contractor at or near the site of the bridge, shall from the time of their being so provided, erected or deposited become, and until the final completion of the said work, be the property of the Minister for the purposes of the said work, and the same shall on no account be taken away, or used, or disposed of, except for the purposes of said work, without the consent in writing of the Engineer. The Minister shall not be liable to the Contractor for any loss or damage whatsoever.

No such material, false works, machinery, plant, buildings and their contents, equipment, articles and things, shall be erected or deposited on premises which are not owned by or leased to the Minister.

And the payment for the use and lease of said material, false works, machinery, plant, buildings and their contents, equipment, articles, things and premises shall be deemed to have been included in the payments in this contract provided for, whether any or all such payments have been made or not, and that no other payment, whatever, shall be due by the Minister for the use, wear and tear, damage or loss of such property.

Upon the completion of the works and their acceptance by the Minister and upon the payment by the Contractor of all such moneys, loss, costs and damages, if any, as shall be due from the Contractor to the Minister, or chargeable against the Contractor under the specifications or supplementary specifications, such of the said material, false works, machinery, plant, buildings and their contents, equipment, articles, things and premises as shall not have been used or converted in the works, or lost, or destroyed, or disposed of by the Minister under power conferred in this contract, shall, upon demand, be delivered up to the Contractor in such condition as they may then be in.

15. His Majesty may, at any time, without payment to the Contractor therefor, send and employ on, in and about the works other Contractors and workmen, with such horses, machinery, tools, plant, equipment, materials, articles and things, as the Chief Engineer may deem necessary to do any work not comprised in this contract, and the Contractor shall afford to them all reasonable facilities, to the satisfaction of the Engineer, for doing such work, the work of the Contractor being interfered with as little as the Engineer may deem practicable.

16. If the Contractor shall, at any time fail, omit or refuse to comply with or perform any of the essential provisions of this contract, or of the specifications or supplementary specifications, which, on his part are to be observed or performed, the Minister may cancel and annul the contract, in which event the Contractor shall have no claim or demand whatever upon or against His Majesty for damages, or for compensation for work done, or material, machinery, plant, buildings or grounds provided, or for any portion of the percentage retained on any estimate, or for any portion of the sum deposited by the Contractor as security as hereinafter provided, and the Minister may take possession of and hold the said work and all materials, false works, machinery, plant, buildings and their contents, equipments, articles, things and premises provided and leased to him as hereinbefore provided and may retain and appropriate to his own use all moneys which may then be unpaid to the Contractor, and the said sums deposited, in order to complete the works herein mentioned, and His Majesty shall be absolutely and forever released from all liability therefor to the Contractor, without, by so doing, relieving the Contractor of any of the responsibilities placed upon him by this contract and by the specifications and supplementary specifications; and any balance spent by the Minister above said sums to complete the works referred to in this contract shall be paid by the Contractor.

17. The Contractor shall be at the risk of, and shall bear all loss or damage whatsoever, and from whatsoever cause arising, which may occur to the works, or any part thereof, until the same be fully and finally completed, delivered to and accepted by the Minister, and if any such loss or damage occur before such final completion, delivery and acceptance, the Contractor shall immediately at his own expense, repair, restore and re-execute the work which has been damaged or destroped.

18. The Contractor shall rectify, to the satisfaction of the Chief Engineer, any defects in the works or which may appear therein, or of which he shall receive notice from the Chief Engineer, and for which he may have been responsible, in the opinion of the Chief Engineer, during the period of thirty days after the date of the final certificate of the completion of the work.

19. The Contractor, his agents and all workmen and persons employed by him, or under his control, shall use due care that no person or property is injured and that no rights are infringed in the prosecution of the work, and the Contractor shall be solely responsible for all damages, by whomsoever claimable, in respect of any injury to persons or to lands, buildings, structures, fences, trees, crops, roads, ways, ships, or property of whatever description, and in respect of any infringement of any right, privilege or easement whatsoever, occasioned in the carrying on of the works or any part thereof, or by any neglect, misfeasance or non-feasance on the Contractor's part or on the part of any of his agents, workmen or persons employed by him or under his control, and shall, at his own expense, make such temporary provisions as may be necessary to ensure the avoidance of any such damage, injury or infringement and to prevent the interruption of or danger or menace to the traffic on any public or private road, and to secure to all persons and corporations the uninterrupted enjoyment of all their rights, in and during the performance of the said works; and the Contractor shall indemnify and save harmless His Majesty from and against all claim and demands, loss, costs, damages, actions, suits or other proceedings by whomsoever made, brought or prosecuted in any manner based upon, occasioned by, or attributable to any such damage, injury or infringement. Provided, however, the Contractor shall not be liable for any damage or loss that may result from the stoppage of navigation during the time and to the extent authorized by the Chief Engineer for the purpose of floating the suspended span into place.

20. The Contractor shall upon the completion of the works remove all false works, buildings, obstructions, unsightly material and temporary structures and clear away all rubbish and surplus and waste materials remaining on or about the works, and place the premises in a neat and tidy condition satisfactory to the Chief Engineer.

21. The Contractor shall, at his own expense, take special precautions to prevent fire occurring in or about the works, and employ his own workmen, to the satisfaction and under the direction of the Engineer, in extinguishing all such fires which may occur; and shall observe and comply with all laws and regulations in force respecting fires, and with all regulations and instructions made and given, from time to time during construction, by the engineer, with respect to fires and the prevention and extinguishing of fires, and shall pay all wages and other outlay occasioned by reason of the observance or compliance with such regulations and instructions.

The Contractor shall, also, at his own expense, at all times during construction and until the final acceptance of the works, keep all buildings and structures insured against loss by fire, in such insurance company or companies and in such amount or amounts as may be approved of by the Engineer, and the policies of such insurance shall be made payable as the interests of the Contractor and His Majesty may respectively, appear, and shall be deposited with the Chief Engineer.

22. The Contractor shall not, without the written consent of the Minister, make any assignment of this contract, or any sub-contract, for the execution of any of the works hereby contracted for; and, in any event, no such assignment or sub-contract, even though duly consented to, shall exonerate the Contractor from liability under this contract for due performance and completion of the works hereby contracted for.

23. Pursuant to the provision of the Statute in such case made and provided, no member of the House of Commons of Canada shall be admitted to any share or part of this contract, or to any benefit to arise therefrom.

24. The Contractor shall comply with and be subject to all the terms, stipulations and conditions contained in the fair wages clauses hereunto annexed, and the said fair wages clauses shall be read with and shall form part of this contract.

25. The Contractor shall promptly pay for all labour, services and materials in or about the construction of the works, and all payments for such purposes shall be made by the Contractor, at least as often as payments are made to the Contractor by His Majesty under this contract; and in the event of failure by the Contractor at any time so to do or if any sum due for labour of any foreman or workman, or for hire of horses, teams or carts upon or in respect of the works, or any part thereof, remains in arrear or unpaid, or if there be at any time found to exist any claims against the Contractor, or any sub-contractor, for labour, teams, tools, plant, equipment, materials, articles or things employed, hired or supplied upon or for the works or any part thereof, or if the Minister has reason to believe that any such payments, sums or claims will not be promptly made or paid, the Minister may, in addition to or in lieu of exercising any powers conferred by the said fair wage clause, at his option, retain out of any moneys due or to become due to the Contractor from His Majesty such amount or amounts as the Minister may deem sufficient to satisfy the same, or pay the Contractor the moneys due him in instalments, giving him from time to time such sums as the Minister or the Chief Engineer deems sufficient to meet such payments, sums or claims or any of them, and withholding the balance until the same are satisfied, or may pay all or any of such payments, sums or claims, rendering to the Contractor the balance due him after deducting the payment so made.

The Contractor shall be estopped from denying the accuracy and correctness of any and all payments so made by the Minister.

The Contractor's pay-rolls, time-books, books of account, invoices and statements shall be at all times open for inspection and extract by the Chief Engineer and any authorized representative of the Minister, or either of them, who shall be assisted in every possible way by the Contractor, to enable the Chief Engineer and such representative to ascertain, as far as possible, the exact payment, sums or claims so due and remaining unpaid by the Contractor.

26. The Contractor shall comply with and the works shall be carried on subject to all regulations for the time being in force pursuant to the Public Works Health Act and all regulations made by any lawful authority and applicable to said works, and all orders given by the Engineer with respect to sanitation or preservation of health on the works. The Contractor shall, at his own expense, make adequate arrangements, to the satisfaction of the Engineer, for the medical and sanitary supervision of all his employees.

27. The Contractor shall protect and shall not remove or destroy, or permit to be removed, covered or destroyed, the stakes, buoys, targets, base lines, plugs, bench marks, and other marks placed on or about the said works by the Engineer or his assistants, and shall furnish the necessary assistance to correct or replace or recover

any stake, buoy, targets, base lines, plugs, bench marks or other marks which through any cause may have been removed, destroyed or covered.

28. The Contractor shall place and maintain on the works such lights, beacons, buoys, or signals as shall be required by the Department of Marine and Fisheries of Canada.

29.—His Majesty, in consideration of the premises, and subject to the performance and observance on the part of the Contractor of all covenants, provisos and conditions in this contract contained, will pay to the Contractor for and in respect of the works, in manner hereinafter stated the price or several prices following, viz.:—

30.—The quantities and measurements (if any) given in the specifications or supplementary specifications are approximate only and no claim shall be made by the Contractor against His Majesty on account of any excess or deficiency, absolute or relative, in the same.

31.—The description or descriptions of the work and materials or any portion or portions of the works, set out or referred to in or covered by any item or items for which a price or prices are given in this contract, include not only the particular kinds of work or materials mentioned in the said item or items, but also all and every kind of work, labour, tools, plant, materials, equipment, articles and things whatsoever necessary for the full execution, completion, and delivery, ready for use, of such respective portions of the work, in accordance with the plans, drawings, specifications and supplementary specifications to the satisfaction of the Chief Engineer. The said price or prices, as a whole, shall cover not only the particular descriptions of work and materials mentioned therein, but also all and every kind of work, labour, tools, plant, materials, equipment, articles and things, whatsoever necessary for the full execution, completion and delivery, ready for use, of the entire work as herein contracted for, in accordance with the plans, drawings, specifications and supplementary specifications, to the satisfaction of the Chief Engineer. In case of dispute as to what work, labour tools, plant, materials, equipment, articles and things are so included or covered, the decision of the Chief Engineer shall be final and conclusive with respect thereto.

32. The said price or prices shall be accepted by the Contractor as full compensation for everything furnished and done by the Contractor under this contract, including all work required but not included in the items hereinabove mentioned, and also for all loss or damage arising out of the nature of the works or the action of the weather, tides, elements, or any unforeseen obstruction or difficulty encountered in the prosecution of the work, and for all failures, accidents, contingencies, plant, labour, materials, staging painting customs duties, rentals, taxes, transportation patent-rights, cost of leases, necessary buildings, medical attendance, removal of erection and damaged material, and all risks of every description connected with the works, and for all expenses incurred by or in connection with the works, and for all loss or damage from whatever cause arising that may happen or occur to the work or any part or portion of it, or to the men, plant, material or tools, and for all expenses incurred by or in consequence of any delay or suspension or discontinuance of the work as herein specified, and for well and faithfully completing the works as in this contract provided.

33.—Cash payments in accordance with the specifications approximately estimated from progress measurements, and computed at the price or prices agreed upon or determined under the provisions of this contract and the specifications, will be made to the Contractor monthly, on the written certificate of the Chief Engineer, stating that the work for, or on account of, which the certificate is granted has been done, and stating the value of such work computed as above mentioned; and the said certificate

shall be a condition precedent to the right of the Contractor to receive any such payment, or any part thereof. The monthly estimate shall be made up at the end of each month and forwarded to the Minister not later than the fifteenth day of the month following, and payment for the same shall be made by His Majesty not later than the last day of the same month after deducting any sums which may be due to His Majesty by the Contractor. The written certificate of the said Chief Engineer certifying to the final completion of the said works to his satisfaction, shall be a condition precedent to the right of the Contractor to receive any balance due him or to have returned to him the sum he has deposited as security as hereinafter provided.

34.—Before making any payment on any progress or final estimate the Minister may require the Contractor to satisfy the Chief Engineer or other authorized representatives of His Majesty that all work performed and materials supplied and all structures built, for which payment is being made are free and clear from all lawful claims or liens under any law for labour, workmanship, materials or otherwise, and the Contractor shall indemnify and hold harmless His Majesty from and against any and all kinds of claims or liens accruing from labour and services performed and material furnished, or otherwise, and any of the same, in or about the works.

35.—The progress measurements and progress certificates shall not in any respect be taken as binding upon the Chief Engineer, or as final measurements, or as fixing final amounts; they are to be subject to the revision of the Chief Engineer in making up his final certificate; and they shall not in any respect be taken as an acceptance of the work or release of the Contractor from any responsibility in respect thereof.

36.—The Contractor shall not have, or make any claim or demand, or bring any action or suit or petition against His Majesty for any damage which he may sustain by reason of any delay or delays from whatever cause arising, in the progress of the work.

37.—Should the amount voted by Parliament and applicable towards payment for the works hereby contracted for, be at any time expended previous to the completion of the works, the Minister or the Chief Engineer may give the Contractor written notice to that effect. Upon receiving such notice the Contractor may, if he thinks fit, stop the work—but shall not be entitled to any payment for work done beyond the amount voted and applicable as aforesaid—until the necessary funds shall have been voted by Parliament in that behalf.

38.—The Contractor shall not bring or permit to be brought anywhere on or near the works any spirituous or intoxicating liquor; and if any person employed on the works be, in the opinion of the Engineer, intemperate, disorderly, incompetent, wilfully negligent or dishonest in the performance of his duties, he shall, on the direction of the Engineer, be forthwith discharged, and the Contractor shall not employ, or permit to remain on the work any person who shall have been discharged for any or all of said causes.

39.—No condoning, excusing or overlooking by His Majesty, or any person acting on His behalf, on previous occasions, of breaches or defaults similar to any one for which any action is taken or power exercised, or forfeiture is claimed or enforced against the Contractor, shall be taken to operate as a waiver of any provision of this contract, or to defeat, affect or prejudice in any way the rights of His Majesty hereunder.

40.—This contract is made and entered into by the Contractor and His Majesty, on the distinct understanding that the Contractor has, before execution, investigated and satisfied himself of the character and topography of the country, the bed, banks, and flow of the river, the rainfall, temperature at different seasons, the dimensions, levels,

location, character and nature of all works, piers, abutments, buildings, constructions, roads, lands, waterways sewers, pipes, and the ownership of the same, the nature and formation of the strata through which excavations, if any, are to be made, or upon which the works have to be built, and all other things, and of every condition affecting the works to be executed and the labour and material to be provided, and that the execution of this contract by the Contractor, is founded and based upon his own examination, knowledge, information and judgment, and not upon any statement, representation or information made or given by, or upon any information derived from any quantities, dimensions, tests, specifications, plans, maps, or profiles made, given or furnished by His Majesty or any of His Officers, employees or agents; and that any such statement, representation or information, if so made, given or furnished, was made, given or furnished merely for the general information of bidders and is not in anywise warranted or guaranteed by or on behalf of His Majesty; and that no extra allowance will be made to the Contractor by, and the Contractor will make no claim against His Majesty for any loss or damage sustained in consequence of, or by reason of, any such statement, representation or information being incorrect or inaccurate or on account of excavating in rock or other difficult ground or of unforeseen difficulties of any kind.

41.—The Contractor hereby and herewith deposits with and delivers to His Majesty the sum of

upon the express understanding that the same shall be held and retained by His Majesty as security for the due and faithful performance, observance and fulfilment by the Contractor of all the covenants, provisos, agreements, conditions and reservations, in this contract contained, on the part of the Contractor to be observed, performed and complied with. Interest upon the said amount shall be paid annually by His Majesty to the Contractor at the rate of three per centum per annum from the date of this contract, while and so long only as this contract is being duly and faithfully performed, observed and fulfilled by the Contractor and until the said amount is returned to or tendered to the Contractor or otherwise dealt with under the provisions of this contract.

In Witness Whereof the Contractor has executed these Presents, and these Presents have been signed on behalf of His Majesty by the Minister and by the Secretary of the Department of Railways and Canals, and the seal of the said Department has been hereto affixed the day and year first above written.

Signed, Sealed and Delivered
by the Contractor, in presence of—

Signed, Sealed and Delivered
by His Majesty, in manner aforesaid,

} Minister of Railways and Canals.

Secretary.

SESSIONAL PAPER No. 104

FAIR WAGES CLAUSES.

The following conditions are incorporated in and form part of the annexed contract between His Majesty the King, represented by the Minister of Railways and Canals, and

(therein and hereinafter called the Contractor), dated the

day of 19

and distinguished by the number

1.—No labourers shall be employed on or about the works hereby contracted for who are not citizens or residents of Canada, but the Minister may in writing waive the provisions of this clause, either in general or to a limited extent, should he deem it expedient to do so.

2.—The minimum rate of wages to be paid by the Contractor for the labour of any employee, or the minimum rate or hire for any team, employed in or about the works, shall be the rate specified in the fair wages schedule hereto annexed for the same or similar class of labour as that in which such employee is engaged, or for the hire of teams respectively.

3.—The number of working hours for employees in the day or week shall be in accordance with the custom of the same or similar trade or classes of labour in the district where the work is being carried on,—to be determined, in case of dispute, by the Minister; and no employee shall be required to work for longer hours, except for the protection of life or property, in case of other emergencies, when necessity therefor is confirmed by the Engineer.

4. In case any labour is required in or about the works for which, in the opinion of the Engineer, no rate is fixed in the said schedule, the Engineer, or other officer authorized by him, may fix the minimum rate of wages payable in respect thereof, which shall not be less than the rate of wages generally accepted as current for competent workmen in the same or similar trades or class of labour in the district where the work is being carried on.

5.—The Contractor shall not be entitled to any payments under this contract in respect of work and labour performed until he has filed in the office of the Engineer a statement, in duplicate, showing the rate of wages by him paid for the various classes of labour and the hire of teams, employed in or about the work, and, if any amounts should then be due and unpaid in respect of such wages or hire, showing in detail the names of the unpaid employees, the class of employment, rate of wages, and the amounts due to each; nor shall the Contractor be entitled to any payments under this contract in respect of materials or other things supplied, for use in or upon the works, until he has filed in the office of the Engineer a statement, in duplicate, showing the prices and quantities of all such materials or things, and if any amounts should then be due and unpaid in respect thereof, showing in detail the names of the unpaid vendors, the quantities, prices, and the amounts due to each, such statements shall be attested, in duplicate, by the Statutory declaration of the Contractor, or of such person on behalf of the Contractor as the Minister may approve.

6.—The Minister or the Engineer, may, as a further condition to such payment at any time require the Contractor to furnish such further or other detailed information as may be necessary to establish to their satisfaction the compliance by the Contractor with the conditions of his contract.

7.—Should the Contractor fail to adhere in every particular to the Fair Wages Schedule hereto annexed, or permit any wages or amounts payable for the hire of

teams to become or remain in arrear or unpaid, or fail to pay any accounts for materials or other things supplied for the works, the Engineer may give notice in writing requiring the Contractor to adhere to such schedule, or to pay such wages, or for such hire of teams, or for such materials or other things, as the case may be. Should the Contractor fail for the period of forty-eight hours after giving of such notice to comply with the terms thereof, the Minister may make such payments as shall be sufficient to effect an adherence with such schedule, or other settlement or discharge of such arrears, or indebtedness for hire or materials or things supplied, and the Contractor in the event of any such payments being made after notice and default, as aforesaid, shall be stopped from setting up, as against His Majesty, the accuracy of any amounts so paid, or the existence or extent of any such indebtedness, and all amounts so paid shall be repaid, at once by the Contractor, or may be deducted from any amounts then or thereafter due by His Majesty to the Contractor.

8. The Minister or the Engineer may, in their discretion, at any time require proof, with such formalities or to such extent as they may deem requisite, of any claim under the said Fair Wages Schedule, or for wages or hire of teams in arrears, or of accounts for materials, or other things unpaid.

9. The words 'work' or 'works', 'Minister', 'Contractor', and 'Engineer', when used herein, shall have the same meanings, respectively, as in the contract of which these Fair Wages Clauses form part.

10. The Contractor shall post and keep posted in a conspicuous place on the works under construction the said Fair Wages Schedule for the protection of the workmen employed, and also keep a proper record of all payments made to workmen in his employ, and the books and documents containing such record shall be open for inspection by the Fair Wages Officers of His Majesty at any time that it may be expedient for the Minister of Labour to have the same inspected.

FAIR WAGES SCHEDULE.

The following is the minimum rate of wages to be paid respectively for the several classes of labour mentioned, or for the hire of teams:

All mechanics, labourers and other persons who perform labour in the construction of the work hereby contracted for, shall be paid such wages as are generally accepted as current for competent workmen in the district in which the work is being performed, and if there is no current rate in such district, then a fair and reasonable rate, and shall not be required to work for longer hours than those fixed by the custom of the trade in the district where the work is carried on, except for the protection of life or property, or in the case of other emergencies. In the event of a dispute arising as to what is the current or a fair and reasonable rate of wages or what are the current hours fixed by the custom of the trade it shall be determined by the Minister of Labour, whose decision shall be final.

These conditions shall extend and apply to moneys payable for the use or hire of horses or teams, and the persons entitled to payment for the use or hire of horses or teams shall have the like right in respect of moneys owing to them as if such moneys were payable to them in respect of wages.

In the event of default being made in payment of any money owing in respect of wages of any mechanic, labourer or other person employed on the said work, and if a claim therefor is filed in the office of the Minister of Railways and Canals, and proof thereof satisfactory to the Minister is furnished, the Minister may pay such claim out of any moneys at any time payable by His Majesty under such contract and the amounts so paid shall be deemed payments to the company.

The company shall post in a conspicuous place on the works under construction the general clause above mentioned for the protection of the workmen employed.

The company shall keep a record of payments made to workmen in its employ. The books or documents containing such record shall be open for inspection by the Fair Wages Officers of the Government at any time it may be expedient to the Minister of Labour to have the same inspected.

BOARD OF ENGINEERS, QUEBEC BRIDGE SPECIFICATIONS—FOR THE CONSTRUCTION OF THE SUPERSTRUCTURE OF A RAILWAY BRIDGE OVER THE ST. LAWRENCE RIVER, NEAR QUEBEC.

In these specifications the words 'Minister,' 'Board,' 'Chief Engineer,' 'Engineer,' 'Work or Works,' shall have the same respective meanings as defined for the purposes of the contract.

1. *Works under contract.* The works referred to in these specifications consist in the making and building of the superstructure of a railway bridge over the St. Lawrence river, near Quebec, complete and ready for traffic, except as otherwise specified in paragraph 7.

2. *Plans.*—The plans mentioned in the schedule hereto attached and the notes on same, shall be considered as a part of these specifications. In case of disagreement betweeen the plans and specifications, the latter shall govern.

3. *General agreement.*—I. The superstructure shall have the general arrangement of spans as per plan No. 1.

II. A clear head-room for ships must extend for 600 feet at the centre of the main span and no part of the steel-work, for that length, shall be under Elev. 251.130, with the maximum loading specified, leaving 150 feet clear above highest water.

III. There must be a clear head-room above the railway tracks of 23 feet above base of rail extending 4 feet on each side of the centre line of track, and there must be a clear space of 8 feet outside the centre line of each track. Tracks may be spaced not closer than 14 feet centre to centre.

4. *General conditions of contract.*—The Contractor must satisfy himself as to the sufficiency and suitability of the design, plans and specifications upon which the bridge is to be built, as the Contractor will be required to guarantee the satisfactory erection and completion of the bridge, and it is to be expressly understood that he undertakes the entire responsibility not only for the materials and construction of the bridge, but also for the design, calculations, plans and specifications, and for the sufficiency of the bridge for the loads therein specified. And the enforcement of any part, or all parts, of the specifications shall not in any way relieve the Contractor from such responsibility.

5. *Custom duties.*—All Canadian and foreign custom duties on material and plant shall be paid by the Contractor.

6. *Weight paid for.*—The Contractor will be paid for the number of pounds of steel remaining in the bridge after all erection material has been removed, but in case such weight exceeds the calculated weight based on the dimensions of material shown on the shop plans (after deducting all erection material) plus two per cent, the Contractor shall be paid for such calculated weight with an addition of two per cent; the weight of paint shall not be included in such calculated weights.

7. *Floor materials.*—All rails and materials for railway tracks above stringers will be furnished and laid by the Minister, except the expansion joints and guard angles, with the screws and bolts therefor, which shall be furnished by the Contractor. All timber and necessary fastenings for two 4-ft. sidewalks shall be furnished and laid by the Contractor.

8. *Conditions of floating suspended span.*—When the suspended span is ready to be floated into place, the Minister shall, if the Contractor so desires, provide and place at the disposal of the Contractor such steamship or steamships, as will afford sufficient power to tow the suspended span to the bridge site. It is to be distinctly understood, however, that the Minister will only furnish such steamships as will be sufficient to move the said span, and the Contractor will have to furnish any additional steamers that may be required to steer or otherwise control the tow. The Contractor will also have to furnish all labour together with all scows, false work, cables, anchors, tackle, or other plant or material that may be required to properly execute the work.

The Contractor will have to assume entire responsibility for the steamship or steamships supplied by the Minister and for the satisfactory carrying out of the work upon which they are employed.

The Minister will, during such time and to such extent as the Chief Engineer considers necessary, stop navigation on the stretch of water required for the floating operations.

9. *Deposit.*—Each tenderer must send with his tender or tenders a cheque accepted by a Canadian chartered bank for five hundred thousand dollars ($500,000), made payable to the order of the 'Minister of Railways and Canals of Canada'. As soon as a tender is accepted the successful Contractor shall deposit with the Minister another similarly accepted cheque made payable to the order of the Minister for such amount as will make the united amount of the two cheques equal to fifteen per cent (15%) of the cost of the works as estimated by the Chief Engineer.

Time being the essence of the contract, if the Contractor whose tender has been accepted neglects or refuses to sign the contract upon being requested to do so by the Minister or to deposit the second cheque mentioned above, the said sum of five hundred thousand dollars ($500,000) accompanying the tender shall be forfeited by the Contractor and shall become the property of His Majesty as liquidated damages.

The total deposit so made by the Contractor shall, in any case, be held by the Minister as security for the due and faithful performance and completion of the contract to the satisfaction of the Chief Engineer and until the delivery to and acceptance of the works by the Minister.

Interest upon the said deposits at the rate of three per cent (3%) per annum will be paid by the Minister to the successful Contractor, as provided in the contract.

10. *Prices.*—It is understood that the prices stated by the Contractor in his tender shall be those upon which he agrees to be paid for the works embraced in these specifications. These prices shall be held to include all failures, accidents, contingencies, plant, labour, material, staging, painting, customs duties, rental, taxes transportation, patent rights, cost of leases, necessary buildings, medical attendance, removal of erection and damaged material and everything necessary for the entire completion of the works. Such prices will also be held to include all loss or damage from whatever cause arising that may happen or occur to the works, or any part or portion of them, or to the men, plant, material or tools.

11. *Mode of payment.*—Payments will be made as follows:

I. On manufactured material certified by the Board to have been delivered at the shops, one-third (1-3) of the contract price per pound.

II. On members certified by the Board to have been completely finished in the shops, one-half ($\frac{1}{2}$) of the contract price per pound, less amount, if any, paid under I.

III. On manufactured material delivered at the site of the bridge, five-eighths ($\frac{5}{8}$), of the contract price per pound, less amount, if any, paid under I. and II.

IV. On members erected complete between panel points and partially riveted, to the satisfaction of the Board, the balance of the contract price per pound, minus one cent (1c.) per pound.

V. As soon as the steel work is completely erected in place, with the exception of painting, an additional amount of one-half ($\frac{1}{2}$) cent per pound.

VI. The balance of the contract price will be paid at the same time as the deposit with the Minister is returned to the Contractor.

VII. No payments will be made on any material until it is delivered on the premises either leased to or belonging to the Minister, and the Contractor will be required to lease to the Minister any shops, mills or other premises in or upon which any material is stored or being manufactured upon which any advance or part payment has been made by the Minister.

VIII. The payments mentioned in items one to six, inclusive, of this paragraph will only be made on material that is to remain in the completed bridge and not on any material required for erection only and which will be removed after the completion of the works.

12. *Monthly estimates.*—No payments will be made to the Contractor except on monthly estimates signed by the Chief Engineer. Estimates will be made up at the end of each month and forwarded to the Minister not later than the 15th of the month following, and payment covering such estimate will be made by the Minister to the Contractor not later than the last day of the same month, after deducting any sums which may be due to the Minister by the Contractor.

13. *Work to be started on both sides of the river.*—The work of erection shall be proceeded with on each side of the river as soon as the main pier is ready. All false work, erection plant and machinery shall be provided in duplicate.

14. *Prosecution of work.*—The work shall be proceeded with as rapidly as possible, so as to secure its completion at the earliest date.

15. *Time of completion.*—The Contractor guarantees the completion of the work upon the thirty-first day of December, A.D. 1915, subject to any extension or extensions of time that may be granted by the Minister on the recommendation of the Chief Engineer, or otherwise. Provided also that, if the piers and other masonry are not finished, the north main pier on November 1, 1910, and all other masonry on November 1, 1911, the Minister shall decide what, if any, extension or extensions of time shall be granted to the Contractor for the completion of the works.

16. *Plans.*—Dimensions where definitely determined, will be marked on all plans exhibited. In no case must dimensions be scaled. All final plans, before any materials are ordered from them, must bear the signature of the Chief Engineer. All drawings exhibited and all final plans shall be the property of the Minister, and no copies of any drawing, blue print or plan, shall be given to any person without the written consent of the Minister or the Chief Engineer.

17. *Test of the completed bridge.*—Before the completed works are delivered to and accepted by the Minister, the Minister may have the works tested under live load. Such live load for the railway tracks shall not be more than Cooper's Class E75. Such test loads are to be furnished by the Minister.

18. *Loads.*—The loads and stresses for which the bridge or some of its parts will be calculated are as follows:

A. Train load, 2 Cooper's Class E60 Engines, followed by a train load of 5,000 lbs. per foot per track, on one or two tracks.

B. Train load, Cooper's Class E75, on one or two tracks.

C. A sidewalk load of 500 lbs. per lineal foot of bridge.

D. A snow load of 500 lbs. per lineal foot of bridge.

E. On sidewalks; dead load of the weight of construction.

F. Track-load; ties, guard rails weighing 670 lbs. per lineal foot of railway track. See section of floor.

G. Weight of steel floor (floor beams and stringers).

H. Weight of steel-work as erected, not included in "E", "F" and "G", but including travellers and false-work, &c., during erection.

I. I wind load normal to the bridge of 30 lbs. per square foot of the exposed surface of two trusses and one and one-half times the elevation of the floor (fixed load), and also on travellers and false-work, &c., during erection.

J. A wind load of 30 lbs. per square foot on a train 14 ft. high (moving load).

K. A wind load nearly parallel to bridge of 30 lbs. per square foot of the projected area of the steel-work and of two trains 14 ft. high on a vertical plane normal to wind, or on travellers, false-work, &c., during erection.

L. Stresses due to a traction load of 750 lbs. per lineal foot on one track.

M. Stresses due to a variation of temperature of 150 deg. Fahrenheit.

N. Stresses due to a difference of temperature of 50 deg. between steel-work and masonry.

O. Stresses due to a difference of temperature of 25 deg. between the bottom chords of trusses when free motion is not allowed.

P. Stresses due to a difference of temperature of 25 deg. between the outer web exposed to the sun and the outer webs of compression members.

19. *Train loads on two tracks.*—The trains on the two tracks shall be assumed to have engines headed in the same direction, and whenever two separate loads give the maximum strains in any member, two trains shall be assumed on each track with length of train and position of engines giving the maximum.

20. *Loads used to determine section of members.*—All the co-existing loads and stresses and the deformation shall determine the section of the different members with the following restrictions:

Load "A" shall be used in all calculations where not otherwise provided.

Load "B' will be used to determine the dimension of the masonry and anchorage and also of the connection of suspended span to cantilever arm and of any members subject to reversal of stresses under live load.

Load "B" will also be used to establish the outline of the bridge so that the deflection due to the load will always leave the clear height as specified in paragraph 3.

Load "C" will be used for floor beams and stringers, and members receiving their maximum strain from a length of moving load covering two panels or less.

Strains produced by "P" will be considered as secondary strains, and loads "O" and "P" will be assumed to co-exist with one-half wind loads "I" and "J."

UNIT STRAINS AND PROPORTION OF PARTS.

21. *Unit strains in cantilever design.*—All parts of the structure shall be proportioned so that the sum of the maximum strains produced by the loads specified

shall not exceed the following amounts in pounds per square inch for carbon steel, when

A = Live load strains for loads as specified;
B = Dead load strains (including snow);
C = All co-existing maximum strains together, except secondary strains;
D = All co-existing maximum strains, including secondary strains.

22. *Tension members in main trusses.*—

A	B	C	D
10,000	20,000	20,000	22,000

23. *Suspenders or any members liable to sudden loading.*—

A	B	C	D
7,000	14,000	14,000	15,400

24. *Wire suspenders.*—

A	B	C	D
22,500	45,000	45,000	49,500

25. *Railway stringers.*—

A	B	C	D
9,000	9,000	16,000	17,600

26. *Floorbeams.*—

A	B	C	D
10,000	10,000	18,000	19,800

27. *Compression members in main trusses.*—

A	B	C	D
$10,000—40^{l}/_{r}$	$20,000—88^{l}/_{r}$	$20,000—80^{l}/_{r}$	$22,000—88^{l}/_{r}$

No compression member built of carbon steel shall, however, be strained more than 15,200 lbs. per square inch, not including secondary strains.

28. *Laterals and sway bracing.*—Take both systems in calculation of strains, disregarding reversal of strains.

29. *Rivets.*—

For compression.. .. .. $16,000—70^{l}/_{r}$

	Bearing.	Shear.
Floorbeams and stringers..	12,000 lbs.	6,000 lbs.
Truss members; Live + Dead..	15,000 "	7,500 "
Truss members; all co-existing maximum strains..	20,000 "	10,000 "
Laterals and sway bracing..	20,000 "	10,000 "

For field rivets reduce above by 10%.

30. *Pins.*—For values of A = 10,000 in tension or over, or $10,000—40^{l}/_{r}$ in compression, and corresponding values of B. C and D. used in calculating the connected member.

Bearing.	Fibre Stress.
20,00 lbs.	24,000 lbs.

For smaller values of A, reduce in proportion.

31. *Nickel steel.*—Increase units given for carbon steel as follows:

Tension.. .. .. 40%
Compression and pins.. .. .. 25%

No compression member built of nickel steel shall, however, be strained to more than 19,000 lbs. per square inch, not including secondary strains.

32. *Units for determining sections.*—The units giving the maximum section shall be used for proportioning the different members; but the Board reserves the right to change the above unit stresses as may be deemed advisable in the light of further tests.

33. *Pressure on masonry.*—

Maximum pressure on bed plates per square inch..	800 lbs.
Maximum pressure on concrete per square foot..	33,000 "

34. *Anchorage masonry.*—Anchor piers shall show a co-efficient of safety of two.

35. *Assumptions and calculations.*—In case of dispute before and after the contract is awarded, the assumptions to be made and modes of calculation to be used shall be the ones made and used in the preparing of the plans exhibited, and the results of which are shown in the strain sheets and plans exhibited. The decision of the Chief Engineer on any such questions shall be final.

36. *Signs '+' and '—.'*—In all strain sheets the sign '+' shall denote compression; the sign '—' shall denote tension.

37. *Statically indeterminate structures.*—The strains in statically indeterminate structures shall be calculated from their elastic deformations and all assumptions made and formulæ used for the calculations must be given in strain sheets to be submitted.

38. *Bending strains.*—All bending strains produced by the weight of the member itself and by loads applied on the member shall be considered as primary strains.

All members shall be proportioned so that the greatest fibre strain due to this bending and axial strain together will not exceed the allowed units for the axial tension or compression in that member.

39. *Secondary strains.*—All strains produced owing to the deformation of the steel-work under any and all loads, either by the absence of pins at the joints or by the friction on pins opposing the turning of members shall be considered as secondary strains.

40. *Alternate strains.*—Members subject to alternate tension and compression shall be proportioned for either stresses. Rivets in connections and splices in all cases shall be proportioned for the sum of both stresses. Material in connections and splices shall be proportioned to resist the larger stress + 25 + of the smaller stress. In no case shall the section be less than the section of the member.

41. *Net section at rivets.*—In calculating the net area of tension members, the rivets holes shall be taken one-eight inch larger than the nominal diameter of rivets before driving.

42. *Rivets.*—In proportioning rivets, the diameter of the rivet before driving shall be used.

43. *Splices in tension members.*—Tension members shall be given full splice in material and rivets.

44. *Splices in compression members.*—All splices in compression members shall be given full strength in material and one-half strength in rivets, except the top and bottom flanges which shall be given full strength in material and rivets.

45. *Net section at pins.*—Pin-connected riveted tension members shall have a net section through the end pin hole at least thirty-three per cent (33%) in excess of the net section of the body of the member and the net section back of the pin hole parallel with the axis of the member, shall not be less than eighty per cent (80%) of the net section of the body of the member. The net section through the intermediate pin holes shall be increased over that of the member by the section cut out by the pin hole.

46. *Latticing.*—The latticing for compression members shall be calculated by assuming the value of $K^1/_r$ in the column formula $Uk = U - K^1/_r$ to be the maximum bending strain in the column produced by its compression. It shall also be assumed that the column will bend in a parabola. If the weight of the member produces additional shear, this must be added.

The same column formula used in proportioning the section of the member shall be used for its lattice bars. When the value of $^1/_r$ for the parts of struts connected by lattice bars is more than the value of $^1/_r$ for the whole strut, the former value shall be used in the calculation of the value of the strut.

47. *Plate girders.*—Plate girders shall be proportioned by their moment of inertia.

48. *Compression flange.*—The gross section of the compression flange shall not be less than the gross section of the tension flange, and the widths of the flange shall not be less than one-twelfth (1-12th) of the distance between its side supports.

49. *Flange rivets.*—The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the depth of the girder at that point, and in addition any load applied directly on the flange. The wheel loads where the ties rest on the flanges shall be assumed to be distributed over three ties.

50. *Web stiffeners.*—Stiffeners shall be riveted to the web as shown in the plans exhibited.

51. *Radius of gyration of compression members.*—Minimum radius of gyration shall be one one-hundreth (1-100th) of the length of member for trusses, and one one-hundred-and-twentieth (1-120th) for lateral and sway bracing struts.

52. *Materials to be used.*—Approach spans, floor-beams, stringers, hand railings, stairways and all rivets shall be made of carbon steel. In case the main part of any member of the trusses is made of nickel steel, all the details and connections of such member shall also be nickel steel. In case the main part of any other member of the bridge is made of nickel steel, the details and connections may be made of carbon steel.

DETAIL OF DESIGN.

53. *Open sections.*—Details shall be so designed that all parts will be accessible for inspection, cleaning, painting and repairs.

54. *Water pockets.*—Pockets or depressions which will hold water shall be provided with satisfactory drain holes, or be filled with acceptable waterproof material.

55. *Symmetrical sections.*—Main members shall be so designed that the neutral axis will be as near as practicable in the centre of section, and the neutral axes of intersecting main members of trusses shall meet at a common point.

56. *Adjustable members.*—Adjustable members shall not be allowed except for erection purposes.

57. *Strength of connections.*—The strength of connections shall be sufficient to develop the full strength of the member, even though the computed strain is less, the kind of strain to which the member is subjected being considered.

58. *Size of material.*—All plates and shapes shall be of the maximum sizes and thickness obtainable.

59. *Minimum thickness.*—No material shall have a thickness of less than $\frac{1}{2}$ inch for all parts of main trusses, carrying calculated strains, except lattice bars which may be 7-16 in. and lattice angles which may be $\frac{3}{8}$ in. The webs and flanges of floorbeams shall have a minimum thickness of $\frac{1}{2}$ inch.

In no case shall any material be less than $\frac{3}{8}$ in. except fillers.

60. *Minimum size of rivets.*—The nominal diameter of rivets shall be at least:—

$\frac{7}{8}$-in. up to $3\frac{1}{2}$-in. grip;
1-in. from $3\frac{1}{2}$-in. to $5\frac{1}{2}$-in. grip;
$1\frac{1}{8}$-in. for $5\frac{1}{2}$-in. grip and over

and the actual diameter of the holes shall be $\frac{1}{16}$-inch larger.

The actual diameter of the rivets will be such as to require, when heated, a slight pressure to force them into the hole. The size of the rivets shall be adjusted to fill this condition.

61. *Pitch of rivets.*—The minimum distance between centres of rivets shall be three diameters of the rivet holes.

The maximum pitch in the angles in the line of strain for members composed of plates and shapes shall be five diameters of the rivet holes. For angles with two gauge lines the maximum shall be twice the above in each line, with rivets staggered.

The maximum distance between stitching rivets in compression members shall be eight times the minimum thickness of any one of the plates connected together.

The maximum distance between stitching rivets on the edges of tension members shall be ten times the minimum thickness of any one of the plates connected.

62. *Edge Distance.*—The minimum distance from the centre of any rivet to a rolled or planed edge shall be $1\frac{1}{4}$ times the diameter of the rivet hole. The maximum distance from any edge shall be eight times the minimum thickness of any one of the pieces connected, but shall not exceed six (6) inches.

63. *Pitch at ends.*—The pitch at the ends of built compression members shall not exceed four diameters of the rivet holes for a length equal to one and one-half times the depth of the member.

64. *Riveting of floorbeams to post.*—The holes in floorbeams for the rivets connecting them to the posts shall be drilled through templets on lines so inclined that, after riveting, the end moment in floorbeams is zero under full dead load and half live load.

65. *Compression members.*—The thickness of plates in compression members shall not be less than 1-24th of the distance between the lines of rivets connecting them to the flanges.

66. *Tie plates.*—The open sides of compression members shall be provided with lattice and shall have tie plates as near each end as practicable. Tie-plates shall be provided at intermediate points where the lattice is interrupted. In main members, carrying calculated strain, the end tie-plate shall have a length not less than the distance between the lines of rivets connecting them to the flanges, and intermediate ones not less than half the distance.

67. *Lattice.*—Double lattice shall be used for all main members in trusses.

The length between rivets of flat lattice bars shall not be more than thirty (30) times their thickness. In secondary truss members and lateral struts single lattice may be used; in which case the length between rivets of flat lattice bars shall not be more than forty (40) times their thickness. The inclination of lattice bars with the axis of the member shall be about 45 degrees for double lattice and 60 degrees for single lattice.

68. *Faced joints.*—Abutting joints in compression members shall be faced.

69. *Pin plates.*—Pin holes shall be reinforced by plates when necessary and at least one plate shall be as wide as the flanges will allow so that the allowed pressure on the pins shall not be exceeded, and so that the strains shall be properly distributed over the full cross-section of the member. These reinforcing plates must contain enough rivets in front of the pin to transfer their proportion of the bearing pressure.

70. *Forked ends.*—When forked ends are used they shall be made of at least twice the sectional area of the member, and at least as strong as the body of the member.

71. *Pins.*—Pins shall be long enough to ensure a full bearing of all the parts connected upon the turned body of the pin. They shall be secured by chambered nuts or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the ends.

72. *Filing rings.*—Members packed on pins shall be held against lateral movement. Filling rings shall have two 1-inch holes with tap screws to allow shield to be forced in.

73. *Expansion.*—Provision shall be made for the expansion produced by a variation of temperature of 150° Fahrenheit.

74. *Rigid bracing.*—Lateral, longitudinal and transverse bracing in all structures shall be composed of rigid members, at least as substantial as those shown on the Board's plans.

75. *Overhead transverse bracing.*—Transverse frames rigidly connected to posts and chords shall be used at each main post and at the ends of the through portion of the bridge. They shall be as deep as the clearance will allow. Other transverse frames shall be used at all points where needed.

76. *Length of bracing.*—All lateral and sway bracing between compression members shall be made at least $\frac{1}{4}$-in. short between field connections.

77. *End bracings.*—Deck spans shall have transverse bracing at each end, proportioned to carry the lateral load to the support.

78. *Bracing to clear ties.*—Lateral bracing in deck spans shall be far enough below the flanges to clear the ties in all cases.

79. *Top flange cover.*—Where flange plates are used, one cover plate of top flange shall extend the whole length of the girder.

80. *Web stiffeners.*—Web stiffeners shall be in pairs. Those over the end bearings shall be on fillers. The outstanding legs shall be as wide as the flange angles will allow, and they shall be brought to a close bearing against the upper and lower flange angles. Intermediate stiffeners shall be crimped over the flange angles. Their outstanding legs shall be not less than 1-30th of the depth of the girder, plus 2 inches The thickness of all stiffeners shall be not less than $\frac{3}{8}$-in. and the rivet pitch in them shall not be over 5 in.

81. *Camber.*—The length of all members of the cantilevers shall be such that under dead load all panel points shall be in straight lines. For the suspended span they shall be in straight lines under maximum loads covering the entire span.

82. *Open joints during erection.*—Open joints during erection shall not be allowed in any part of the trusses.

83. *Eyebars.*—The eyebars composing a member shall be parallel to the axis of the truss. In case this is found impossible permission to use a maximum inclination of any bar limited to 1 in. in 16 feet must be obtained from the Chief Engineer.

84. *Number and size of wire suspenders at end of suspended span.*—The suspenders shall be made of the size required to meet the specifications. The number of suspenders shown on the drawings exhibited shall preferably be increased, when shop details are made so as to keep their diameter under two and one-half inches if practicable.

85. *Size of wire.*—The wire used shall not be less than No. 8 U.S. gauge.

86. *Wire splices.*—The suspenders shall preferably be made without intermediate splices. If this be found impossible on account of the length of wire required, the splices shall have a strength of at least 95 per cent of the ultimate strength of the wire, so made that they will resist the tendency to open or part during the operation of winding.

87. *Size of splices.*—The splice may consist of a sleeve not more than $\frac{3}{8}$ inch in diameter with right and left-hand threads, the wires for shop splices having cold rolled threads and mitred ends for locking the splice. All splices shall be carefully soldered in a manner acceptable to the Engineer.

88. *False works on concrete pedestals.*—All false work shall rest on concrete pedestals built at least five (5) feet deep into the ground.

89. *Permanent stairways, &c.*—The Contractor shall design, provide and erect permanent stairways with hand railings at both sides of the bridge at each end portal of the anchor arms and suspended span, giving access from the floor to the top chords, and also one permanent staircase leading from the floor to the top of each main and anchor pier, or twelve in all.

The Contractor shall also design, provide and erect a permanent walk with hand railings on each side, for the whole length of both top chords and across the ends of the suspended truss and anchor arms and across the bridge at the main posts over both main piers.

The permanent stairs shall be made of checkered steel or cast iron, and the walks of wood, all firmly held in place.

Hand railings may be made of wire ropes supported on steel standards securely held in position.

90. *Traction brakes.*—The Contractor shall also provide and erect, between the suspended span and the cantilever arms, effective brakes to prevent motion of the suspended span under traction forces.

91. *Modification to plans exhibited.*—If possible, all top chord supports shall be given the same appearance in elevation, and all top laterals be given the same depth.

STRAIN SHEETS, PLANS AND QUANTITIES.

92. *English units to be used.*—All strains given must be in 1,000 lbs. units, and English weights and measures are to be used.

93. *Erection plans.*—The Contractor shall submit plans showing clearly the method of erection and traveller proposed, so that erection strains may be readily checked.

94. *Strain sheets.*—The Contractor offering his own design must furnish complete strain sheets giving the primary and secondary strains under all conditions of load, during and after erection, and when requested to do so, he must, to facilitate checking, furnish in detail the calculations by which his strains were obtained.

Separate strain sheets must show all strains:

I. From uniformly distributed dead load;

II. From all other dead loads;

III. From live load;

IV. From wind;

V. From temperature;

VI. From traction;

VII. From the maximum co-existing loads.

95. *Section of members.*—The section of all members must be given in detail on the strain sheets and the radii of gyration of all built up members must be shown.

96. *Plans to be furnished with tender on Contractor's plans.*—The plans submitted must show the details of the make-up of all truss members and their splices, of the floor, of the laterals and sway bracings and all connections, of the lacing of all compression members and of the pedestals and anchorages.

The plans submitted must also show all deflections of all parts under the maximum cases of loading specified.

The strain sheets and plans submitted must give all the information needed for determining the adequacy and the agreement with the specifications of the proposed design and for judging the difficulties and the time required for the erection.

97. *Quality of material.*—The structure shall be built entirely of steel in accordance with the attached stress and material diagrams as may be modified to conform with the lengths of spans fixed, or to be fixed, by the Board, the loads provided for in this specification and the unit stress (subject to revision as per paragraph 32 provided), set out in the same.

The contract price per pound applies to the necessary alterations in the sections of members to conform with the provisions of this paragraph as above set out; provided, however, all members of the structure shown on the attached drawings as of nickel steel or of carbon steel, respectively, shall remain of like material on the revised plans.

If the Board should substitute nickel steel for carbon steel in any member, the Contractor shall be paid the contract price per pound plus three and one-quarter ($3\frac{1}{4}$) cents per pound, on the finished weight of such nickel steel; or if the Board should substitute carbon steel for nickel steel in any member, the Contractor shall be paid the contract price per pound less three and one-quarter ($3\frac{1}{4}$) cents per pound on the finished weight of such carbon steel.

98. *Masonry piers.*—Contractors offering their own plans will also send plans of the masonry abutments and piers required (other than the main piers), subject to these specifications.

99. *Railway tracks.*—The railway tracks will be built as per drawing exhibited, with two stringers 8 feet apart under each track.

100. *Strain sheets and plans after contract is awarded.*—(1) As soon as the contract has been awarded the Contractor shall furnish all erection plans, strain sheets and deformation diagrams and details in connection therewith or incidental thereto, to conform with the plans and specifications submitted or accepted by the Minister, all of which erection plans and the details in connection therewith or incidental thereto shall be subject to the approval of the Chief Engineer, and any substitution for, alteration in or modification of any such erection plans, submitted or approved by the Minister, shall be subject to the joint approval of the Board and the Contractor.

(2) The Contractor shall furnish strain sheets and deformation diagrams together with all detailed calculations in connection therewith, or incidental thereto, or in connection with or incidental to the contract work covered, or intended to be covered thereby, which strain sheets, diagrams and detailed calculations shall be subject to the approval of the Chief Engineer, and any substitution for, alteration in or modification of any such strain sheets, diagrams and any such detailed calculations shall be subject to the joint approval of the Board and of the Contractor.

(3) The Contractor shall furnish all shop drawings for the approval of the Chief Engineer and shall not order or manufacture any materials in connection with or incidental to the contract work, or any part thereof, or execute any work, covered, or to be covered by such drawings or any of them, under the contract, plans and specifications as a part of such contract, or any of them, until such shop drawings have been first approved by the Chief Engineer.

IV. No plan, drawing, strain sheet or other document shall be deemed to have been properly approved until it has been signed by the Chief Engineer.

101. *Size of plans.*—All plans, strain sheets, &c., made by the Contractor after the contract is awarded, shall be made on sheets of uniform width.

102. *Where final plans have to be made.*—To prevent delays, all drawings and strain sheets, after the contract is awarded, shall be made at one place in Canada, and all shop drawings shall be made in full detail according to the best American practice, using English measures.

The principal assistant engineer, with a sufficient staff, may be sent to the place where the drawings and strain sheets, referred to above, are made, so as to check all calculations and plans without delay; in which case, the Contractor, at his own cost, shall provide such staff with a private office and such desks, seats, tables, chests of drawers for plans, &c., as will be found necessary for the proper performance of their work.

103. *Erection strain sheets and plans.*—The erection plans shall show all travellers, machinery, lifting tackle, gripping apparatus, temporary members, false work, &c., in full detail so that their weight may be accurately ascertained. Every stage of erection shall be carefully planned showing position of travellers, locomotives, cars and other loads, so that the strains in the different permanent members of the bridge, temporary members and false works, as well as the stability of the structure and false work, under maximum conditions of loading, wind and temperature, may be fully provided for.

104. *Dimensioning of truss members for erection strains.*—In dimensioning truss members for erection strains the calculated weight of travellers, locomotives, cars, &c., shall be increased 10% to cover any inaccuracy in the estimated loads. This, however, shall not apply to wind loads.

105. *Final strain sheets.*—Strain sheets shall be made by the Contractor in at least as much detail as in the strain sheets exhibited, for all loading separately, and also

added together, as per these specifications. Such strain sheets shall be corrected from time to time as the work proceeds on the shop and erection plans.

They shall be considered complete and satisfactory, and approved only when the exact weights and loads have been ascertained and checked by the Chief Engineer.

106. *Shop plans.*—Shop plans shall be approved only when they have been made to conform with the strain sheets and when such plans and strain sheets agree absolutely.

107. *Floating the suspended span.* The suspended span as shown on drawing No. 1 and the detail drawings exhibited, has been designed for being floated into position and not for being erected by cantilevering out.

108. *Copies of plans to be furnished by the Contractor.*—The Contractor shall furnish the Minister with five copies of all plans made for or in connection with this work, as well as all copies needed by the inspectors. At least two of the copies to be furnished shall be made on blue print linen.

WORKMANSHIP.

109 *General.*—All parts of the works shall be built in accordance with the approved plans.

The workmanship and finish shall be the best that the most suitable modern machinery and skilled labour to be obtained can give, to meet these specifications.

110. *Straightening material.*—Material shall be thoroughly straightened in the shop by methods that will not injure it, before being laid off or worked in any way.

111. *Planed edges.*—All sheared edges shall be planed off at least $\frac{1}{8}$ in.

All chipping, whether of rivets or other parts, shall be done in a neat workmanlike manner without breaking out of metal. Each chipped surface shall be finished off with a file.

Where metal is chipped or planed out of a plate or shape all concave corners shall be rounded off to a radius of at least 2 inches (2″) unless shown otherwise on the plans.

112. *Rolled edges.*—Rolled edges through which strains are transmitted by bearing shall be treated like sheared edges.

113. *Sub-punched and reamed work.*—Members made entirely of carbon steel, except I-beams, may be sub-punched and reamed, but no punching shall be allowed on material over $\frac{11}{16}$ in. thick.

114. *Drilled work.*—All members built partly or entirely of nickel steel, all I-beams and all carbon steel more than $\frac{11}{16}$ in. thickness shall have all holes drilled after assembling, and all parts not riveted before shipping match-marked.

115. *Templets.*—The templets shall not be applied to any material unless it is perfectly straight. They must lay flat without any distortion while the marking is being made.

116. *Reaming.*—Punched holes shall be made with a punch $\frac{3}{16}$ in. smaller in diameter than the nominal size of the rivets and shall be reamed to a finished diameter of not more than $\frac{1}{16}$ in. larger than the rivet.

117. *Reaming after assembling.*—Reaming of punched holes shall be done after the pieces forming one built member have been assembled and firmly bolted together to the satisfaction of the inspector.

Holes for field connections other than field splices of main members shall be reamed or drilled, as the case may be, to a steel templet at least 1 inch thick.

Reaming shall be done with twist drills working without vibration so as to obtain a hole perfectly cylindrical and perpendicular to the plane of the metal.

If it be necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be allowed.

118. *Removing burrs and fins.*—Before assembling and after drilling, reaming and planing, all burrs and fins shall be removed from punched, drilled or reamed holes and sheared edges.

After the pieces are reamed every hole shall be gone over with a countersinking tool cutting off the sharp edges of the hole and making a fillet of at least $\frac{3}{16}$ in. under each rivet head.

119. *Size of rivets.*—The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet.

120. *Punching.*—The diameter of the die shall not exceed that of the punch by more than $\frac{1}{16}$ of an inch.

Punching must be accurate so that all parts of the hole shall be cut by the reamer.

121. *Use of large rivets.*—Wherever in riveted work the punching is not close enough to permit the reamer to properly clean up all parts of the holes, such holes must be reamed out for the next larger size rivets. When holes cannot be cleaned up for the next larger sized rivets, the parts inaccurately punched shall be rejected.

122. *No heavy drifting.*—Under no circumstances will heavy drifting be permitted.

123. *Planing edges.*—All plates shall be strongly held against displacement when edges are being planed.

124. *Drilling rivet holes in built members.*—All drilling shall be done after the pieces forming one built member have been assembled and firmly held together.

Drilling shall be done with machines working without vibration so as to obtain a hole perfectly cylindrical and perpendicular to the plane of the metal.

Drills shall be sharpened often enough so as to leave a smooth surface to the interior of the hole and shall be rejected when they are worn out to 1-64th in. below gauge.

125. *Drilling rivet holes in splices.*—When compression members are spliced on both sides, the splicing material on one side shall be drilled with one of the spliced portions of the member and the splicing material on the other side shall be drilled with the other portion of the member. The two portions of the member shall then be faced, if required, and assembled together to exact length and held firmly in position. The half drilled splicing material shall then be bolted securely in place and the blind holes drilled through the holes of the member as a templet.

126. *Members to be straight.*—The several pieces forming one built member shall be straight and fit closely together, and finished members shall be free from twists, bends and open joints.

127. *Assembling compression members.*—All compresion members between end pins shall be completely assembled in the shops. The different parts shall be firmly held together by turnbuckles before the final drilling of splicing material. Before taking apart, all pieces shall be permanently match-marked. The shoes and such other parts of the work as the Engineer shall deem necessary to assemble completely in the shop, to insure proper fit in the field, shall be so assembled.

128. *Finish of joints.*—After the whole member between splices is assembled and completely riveted up with splice holes bolted, abutting joints in compression members shall be truly faced so as to have even bearings when perfectly aligned.

This facing on the main members of the trusses shall be done with planing machines. Rotary cutters shall not be allowed.

129. *Webb stiffeners.*—The ends of stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

130. *Splice plates and fillers.*—Web splice plates and fillers under stiffeners shall be cut to fit exactly between flange angles.

131. *Webb plates.* All buckled web plates shall be rejected. Web plates of girders which have no cover plates, shall not project above the angles and never be more than $\frac{1}{16}$ in. below a true plane coincident with the roots of the angles.

132. *Connecting angles.*—The outstanding legs of all connection angles connecting stringers to floorbeams or floorbeams to posts, chords, or other members, must not exceed an angle of 90° by more than $\frac{1}{8}$ in. at the end of the longer leg.

In fitting these angles to the stringers or floorbeams, they shall be so fitted that the exact length is measured to the root of the angles, the two roots being in exactly the same plane. The entire end of the assembled member shall then be faced, so as to provide against any reduction of area of the angle at the root of such facing, and in such a way as to secure a true surface for the whole width of the connection, and to allow all parts to be drawn together without any strain in the rivets.

133. *Assembling before riveting.*—Riveted members shall have all parts well pinned up and firmly drawn together with a sufficient number of bolts before riveting is commenced. Care shall be taken to see that no chips from drilling or reaming have been left between the different parts. The surfaces coming in contact shall each be painted before being bolted together.

134. *Rivet forges.*—Rivets, both in the shop and in the field, shall be heated in oil, gas or hard coal furnaces of a form approved by the Engineer. Hand forges can be used only in special cases by permission of the Engineer.

135. *Heating rivets.*—The rivets shall be heated in the furnace at the highest possible temperature without burning, and must be driven without delay. The head of the rivet must be at least at the same temperature as the body. Rivets that 'spit' on being taken from the furnace shall be thrown away.

Any rivet heater who is not able to heat the whole of a rivet at the same bright heat without burning, shall be immediately discharged.

136. *Removing scale.*—Before the hot rivet is put in place any scale formed during heating shall be removed.

137. *Driving rivets.*—Rivets shall be driven by pressure tools. Where this is found impossible pneumatic hammers shall be used. As soon as the pressure becomes inadequate, riveting must stop until the pressure has been raised.

138. *Rivets.*—The rivet heads must be hemispherical and of uniform size, for the same sized rivets, throughout the work. They must be full and neatly made and even show a small rounded burr to prove that the rivet was long enough. If the burr so formed is unsightly, it shall be neatly cut with a hand chisel. Heads must be concentric with the rivet holes and the connected pieces thoroughly pinched together. Caulking or re-cupping is expressly forbidden.

139. *Snaps.*—The snaps used shall be of a pattern approved by the Engineer. They must have flat edges to prevent cutting into the plates and when in use must be normal to the surface of the member.

140. *Bad rivets.*—All rivets with crooked or cracked heads, or heads not formed centrally on the shank, or rivets which are loose, either in the hole or under the shoulder shall be removed as soon as marked by the inspector, and replaced.

141. *Cutting rivets.*—If it is found that the cutting and removing of rivets spoils the holes or the material, the rivets shall be removed by drilling.

142. *Discharging riveters.*—Any gang of riveters in whose work too many defective rivets are found will not be allowed to do any further riveting on these works.

143. *Dollys.*—All dollys shall be cup dollys to fit the rivet heads, as no flat heads will be allowed except where specified on the shop plans.

144. *Eyebars.*—Eyebars shall be straight and true to size, neatly and smoothly finished, and shall be free from twists, folds in the neck or head, or any other defects. All small cracks in the heads or neck shall be carefully cut out, and if found too deep shall cause the bar to be rejected. Heads shall be made by upsetting, rolling or forging, but no patching at the forge fire will be allowed on bar or head.

Welding will not be allowed.

The forms of heads will be determined by the dies in use at the works where the eyebars are made, if satisfactory to the Engineer, but the Contractor shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck (unless authorized by the Chief Engineer before the drawings are made) shall be at least equal to and shall not exceed, by more than $\frac{1}{8}$ inch the thickness of the bar.

The heads shall be neatly and smoothly finished to the size and form given on the approved shop drawings, and be symmetrical about the axis of the bar.

145. *Boring eyebars.*—Before boring, each eyebar shall be properly annealed and carefully straightened. Pin holes shall be in the centre line of bars and in the centre of heads. The eyebars of each panel shall be piled on each other at the shops and the pins for which they are bored shall be passed through the holes at both ends of the bars at the same time without forcing.

146. *Annealing.*—Air quenching and annealing in special gas furnaces may be specified before the date at which the tenders are to be received. If no such specification be issued the choice of the mode of annealing will be left to the Contractor.

147. *Gradual heating.*—The bars must be gradually raised to the required temperature for upsetting or annealing and not thrust cold into a highly heated furnace.

148. *Wire suspenders.*—The method of making the strands shall be selected by the manufacturer, but must be approved by the Chief Engineer, and give, in full size tests, the specified requirements.

149. *Binding strands.*—When all the wires have been laid in place around the shoes, under suitable and even tension, they will be bound together by bands to keep them in their proper position.

These bands will be composed of five or six turns of No. 10 U.S. gauge wire, securely locked and will be placed at intervals not to exceed two feet.

150. *Cable shield.*—The cable shield for filling the interstices between the wires of the strands shall be some form of neutral mineral oil or other material of composition and consistency approved by the Engineer. It shall be applied so as to thoroughly and permanently fill the interstices between the wires.

151. *Straining before boring.*—All suspenders before boring shall be put under a tension of at least 40,000 lbs. per square inch for at least one hour, with the shoes securely attached.

The shoes shall then be bored under an even tension for all suspenders of about 10,000 lbs. per square inch.

To ascertain the probable stretch of such suspenders the manufacturer, at his own cost, shall first finish, build and test one after the other, so as to remedy possible defects, three suspenders of the length prescribed and ascertained their stretch under loads of 10,000, 20,000, 30,000 and 40,000 lbs. per square inch. In case of non-uniformity in the results, the manufacturer at his own cost, shall furnish, build and test additional suspenders until sufficient uniformity be obtained.

152. *Covering of suspenders.*—The suspenders shall be thoroughly protected from the weather. The protection shall be so designed in as many parts as will make them easy to handle and so that they may be readily removed to allow inspection of all parts, and easily put back in place.

153. *Pin holes.*—Pin holes shall be bored true to gauges, smooth and straight, and at right angles to the axis of the member and parallel to each other.

The boring shall be done at one operation on the entire members after all the shop riveting has been completed.

154. *Location of pin holes.*—All pin holes shall be drilled in their exact positions within 1-32 in. and any template or other means or apparatus required for checking said positions, without any chance of error over 1-32 in. shall be furnished by the Contractor.

155. *Measurement of members with pin holes.*—Measurements of lengths of members with pin holes shall be taken between bearing surfaces of such pin holes and not centre to centre.

156. *Size of pin holes.*—The diameter of pin holes shall be 1-50th in. larger than that of the pin for pins up to six (6) in. diameter and 1-32nd in. for larger pins.

157. *Pins over six inches diameter.*—Pins over 6-inch diameter shall be forged and must be sufficiently worked under the hammer to insure sound material.

158. *Pins and rollers.*—Pins and rollers shall be accurately turned to gauge and shall be straight and smooth and entirely free from flaws. All pins over six (6) inches shall have holes at least two (2) inches in diameter, drilled exactly in the centre.

159. *Castings.*—All castings shall be steel castings and shall be annealed.

160. *Welds.*—Welds in steel will not be allowed.

161. *Bed plates.*—Expansion bed plates shall be placed true and smooth. Cast wall plates shall be planed top and bottom. The cut of the planing tool shall correspond with the direction of expansion.

162. *Pilots nuts.*—Pilot and driving nuts shall be furnished for each size of pin in such numbers as may be ordered.

163. *Shipping details.*—Pins, nuts, bolts, rivets and other small details shall be boxed or crated.

164. *Weight.*—The weight of every piece and box shall be marked thereon in plain figures.

165. *Standard tapes.*—All tapes or other measuring apparatus shall be tested so as to absolutely conform to the chosen strandard. Tapes shall be standardized lying flat and supported on their entire length under a tension of ten (10) pounds.

166. *Tension on tapes.*—All measurements shall be made with tapes lying flat and supported at frequent intervals, firmly held at one end and under a permanent tension of ten (10) pounds.

All important measurements shall be made by the Engineer himself.

167. *All tapes to be furnished by the Contractor.*—All tapes and attachments needed by inspectors in the shoes and during erection shall be furnished by the Contractor.

SHIPPING AND ERECTION.

168. *Loading, &c.*—At all stages of the work the material shall be handled with the greatest care to prevent any deformation, bend or twist of the members or any of their parts.

Cranes and special gripping apparatus for every piece approved by the Engineer, shall be provided for this purpose as no skidding will be allowed. The Engineer shall have the absolute right to stop and prevent any handling which he may deem to be injurious to any part of the material and his orders shall be obeyed at once.

Material shall be loaded with the greatest care and to the satisfaction of the Engineer, so as to prevent injury in transit.

169. *Shipping suspenders.*—Suspenders shall be shipped with their shoes in place and firmly connected to them, be laid on the cars without bends and thoroughly protected from the weather. They shall be handled throughout with the greatest care.

170. *Weighing.* The inspector shall be notified before the weighing of any material is done, and copy of the weights shall be immediately sent to the Engineer.

The materials may be weighed before or after painting, but no allowance for painting after weighing shall be made.

The weight of field rivets paid for shall be the weight of the rivets actually left in the bridge.

171. *Storing material.*—All material, both in the field and at the shops, must be stored as to prevent injury to it, and to prevent, as far as possible, any accumulation of water or dirt on it.

Stringers and floorbeams must be so stored on edge and not be laid on their sides.

172. *Inspection.*—When the material is unloaded it shall be re-inspected before erection.

173. *Erection.*—Erection shall be proceeded with according to the approved programme.

All main members, between panel points, shall be completely riveted before another main panel is erected.

174. *Bolts and drifts.*—Two-thirds of the rivet holes in erection splices and connections shall be filled up with bolts and one-third with drift pins, equally distributed throughout the joint. The diameter of erection bolts and drift pins, and the shape of drift pins must be approved by the Engineer. Before riveting, all bolts shall be screwed up as tight as possible. Not more than one-third of the holes not filled up

with rivets shall at any time be without bolts properly distributed to ensure a thorough pinching of the materials.

175. *Mode of erection.*—The cantilevers may be erected either by first building the shore arm complete, or by starting on both sides of the main piers. In the latter case, a concrete pier shall be built at the first panel point from the main pier towards the anchorage, and the stability of the works under wind and temperature shall be secured by these two supports alone.

The cost of said concrete piers and concrete foundations under the false work shall be borne by the Contractor.

In any case the shoes shall first be put in place and securely bolted to the masonry and the erection of the bottom chord shall start from the shoes.

176. *Anchorage.*—All anchorage steel built in the piers shall be laid by the Contractor. It shall be manufactured, shipped and erected so as not to delay the Contractor for masonry.

177. *Reversed strains during erection.*—Whenever tension members have to temporarily carry compression during erection, they shall be so packed and stayed as to be able to safely carry said compression.

178. *Cantilevering out suspended span.*—In case the suspended span is erected by cantilevering out, its erection shall be started only after the Chief Engineer is satisfied that the final connection can surely be made before winter interrupts the work.

179. *Surveys and location.*—The Contractor shall make all necessary measurements to check the location of the masonry piers and abutments and a complete agreement as to these measurements must be arrived at between the Contractor and the Chief Engineer before erection begins. Any error between the plans and the masonry as built shall be corrected in the dimensions shown on the plans.

The Contractor shall also locate the shoes, anchorages and all other parts of the bridge and must come to a complete agreement on said location with the Chief Engineer.

And the Contractor shall be held entirely and completely responsible for any errors in the measurements and locations mentioned in this paragraph.

180. *Holes for stone bolts.*—Holes for stone bolts connecting the shoe to the pier shall be drilled in the masonry with the greatest care so as not to split the stone, as soon as all the shoes have been placed in their final positions.

181. *Filling with concrete.*—The interior of any part of the shoes shall be filled with cement concrete, and cement mortar and grout where and when ordered by the Engineer.

182. *Open joints during erection.*—See paragraph 82.

183. *Web members in tension.*—All pins, of each panel, in web members made of several lengths of eyebars, shall be kept in straight lines at all stages of erection.

184. *Workmanship.*—All other pertinent clauses of these specifications shall apply to erection.

185. *Maintenance of staging, false-work, &c.*—The Contractor shall keep all staging and false work in a safe condition, and provide such temporary stairways, gangways, staging, rope railing, &c., as the Engineer may direct to allow a thorough inspection of the work during construction.

MATERIALS.

Rolled carbon steel.

186. *Furnace used.*—All structural steel shall be made in an open-hearth furnace.

187. *Decarburization.*—During the reduction of steel in the open-hearth furnace decarburization below 0·12 per cent of carbon will not be allowed.

188. *Phosphorus and sulphur in stock.*—No stock used in the open-hearth furnace shall contain more than .10 of one per cent of phosphorus or more than .07 of one per cent of sulphur.

189. *Iron ore.*—The use of iron ore for the reduction of carbon in the furnace charge will be permitted according to usual and good practice.

190. *Recarburization.*—The recarburization of steel and addition of manganese shall be performed in a careful manner, giving the most uniform results and to the satisfaction of the Engineer.

191. *Chemical requirements.*—The ladle tests of steel as usually taken shall not contain more than the following proportions of the elements named.

	Acid.	Basic.
Phosphorus	.06 per cent.	.04 per cent.
Sulphur	.04 "	.04 "
Manganese	.70 "	.70 "
		No. chromium to be used.
Silicon	.10 "	.10 per cent.

It is desired that the carbon contents be as small as possible to meet the specifications.

192. *Rivet steel.*—The ladle tests of the carbon rivet steel shall not contain more than .03 of one per cent, of phosphorus, and not more than .03 of one per cent of sulphur.

193. *Ingots.*—The amount of discard from the top and bottom of ingots must be sufficient to insure steel of uniform quality, free from piping and undue segregation.

Slab ingots shall not be allowed.

194. *Finished product.*—The finished material shall be free from injurious seams, flaws or defective edges, and have a clean smooth finish.

It shall be true to section. The variation in weight shall be in accordance with the standard specifications of the American Society for testing materials.

195. *Physical requirements.*—Specimens cut from the finished material shall show the following physical properties:—

Material.	Ult. Strength. (Lbs. per square inch.)	Minimum Yield Point. (Lbs. per square inch.)	Minimum Elongation. (Per cent. in 8 inches.)	Minimum Reduction. (Per cent of area.)
Shapes and plates up to and including 1 in. thick	62,000 to 70,000	35,000	$\frac{1,500,000}{\text{ultimate.}}$	44 per cent.
Plates over 1 in. thick	62,000 to 70,000	33,000	22%; 20 % for sheared plates.	40 per cent.
Rivets	48,000 to 56,000	28,000	$\frac{1,500,000}{\text{ultimate.}}$	50 per cent.

Yield to be determined by drop of the beam.

Speed of machine for testing samples to be such that material under tension will not elongate more than one inch in two minutes.

196. *Bending tests.*—Specimens cut from plates, bars and shapes two inches wide shall bend cold 180 degrees around a rod of a diameter equal to the thickness of the specimen; when at or above a red heat, 180 degrees flat.

Specimens cut from rivet rods shall bend 180 degrees flat when cold, or when at or above red heat. A test piece two inches long when heated to a bright cherry red shall flatten longitudinally under the hammer to a thickness of $\frac{1}{4}$ inch without cracking on the edges.

Full sized sections of eyebar material as rolled without annealing shall bend cold about a rod of diameter equal to twice the thickness of the bar.

All specimens in bending tests must show no signs of cracking on the outside of the bend.

197. *Fracture in tension.* The fracture of all tension tests shall show a fine, silky texture, of a uniform bluish gray or dove colour, free from black or brilliant specks, and show no sign of crystallization.

ROLLED NICKEL STEEL.

198. *Furnace.*—All nickel steel shall be made in an open-hearth furnace. It shall be made in the same manner and of the same stock as specified for rolled carbon steel with the addition of nickel.

199. *Chemical requirements.*—The ladle test shall contain not less than 3.25 per cent of pure nickel, and not more than the following proportions of the elements named.

	Acid.	Basic.
Phosphorus	.06 per cent.	.04 per cent.
Sulphur	.04 "	.04 "
Manganese	.70 "	.70 "
		No. chromium to be used.
Silicon	.10 "	.45 per cent.
Carbon	.45 "	.45 "

200. *Heating and rolling.*—Care shall be taken in the heating and rolling of nickel steel to prevent the formation of heavy scale. The material must not be pitted

by rolling the scale into it. All material with pitted or heavily-scaled surfaces, or with ragged edges, will be rejected.

201. *Physical Requirements.*—Nickel steel for plates and shapes in the finished material must meet the following physical requirements:—

Ultimate strength, 85,000 to 100,000 lbs. per sq. in.

Yield point, 50,000 lbs. per sq. in. minimum.

Elongation in 8 inches (per cent) $\frac{1,600,000}{\text{ultimate}}$

up to 1″, with a reduction of 1% for every $\frac{1}{4}$″ increase in thickness but never less than 14%.

Reduction of area 40% up to and including $\frac{3}{4}$″ in thickness decreasing by 2 for every $\frac{1}{4}$″ over $\frac{3}{4}$″.

Nickel steel for pins in the finished material must meet the following physical requirements:—

Ultimate strength, 90,000 to 105,000 lbs. per sq. in.

Yield point, 55,000 lbs. per sq. in. minimum.

Elongation in 2 inches (per cent) $\frac{1,800,000}{\text{ultimate}}$ minimum.

Reduction of area, 35 per cent minimum.

202. *Bending tests.*—Specimens of nickel steel not less than 2″ wide and of the full thickness of the material as rolled shall bend cold 180° around rods of the diameters specified below for the various thicknesses, without fracture on the outside of the bend.

For material up to $\frac{1}{2}$″ incl.	180″	around	D=1T.
" over $\frac{1}{2}$″ and up to $1\frac{1}{2}$″ incl. . . .	180″	"	D=2T.
" over $1\frac{1}{2}$″.	180″	"	D=3T.

Angles of all thicknesses shall open cold to an included angle of 150° and close to an angle of 30°, without a sign of fracture.

STEEL CASTINGS.

203. *Furnace.*—Steel for castings shall be made in an open-hearth furnace.

204. *Stock.*—At least one-third of all stock used for steel castings shall be pig-iron; and, when scrap is used, it shall be of a kind and quality satisfactory to the Engineer.

205. *Decarburization.*—During the reduction of the steel in the furnace, it shall not be decarburized below ·10 of one per cent.

206. *Use of iron ore, &c.*—In making steel for castings, the use of iron ore, ferro-silicon, ferro-manganese and spiegeleisen will be allowed according to usual and good practice.

297. *Chemical requirements.*—The ladle test of steel for castings shall not contain more than the following proportions of the elements named:—

Phosphorus.	·04	of one per cent	for basic steel.
Sulphur.	·06	"	"	acid steel.
Manganese.	·75	"	"	
Silicon.	·35	"	"	

208. *Annealing.*—All steel castings shall be carefully and thoroughly annealed in a manner approved by the Engineer, and shall have a fine grained or silky fracture.

209 *Soundness of castings.*—All castings shall be sound and free from shrinkage cracks and as free from sand holes and blow holes as the latest and best practice can produce. The Engineer shall be the final judge as to whether a defect is sufficient cause for rejection. Every casting which contains a blow hole or blow holes, or any other cavity or flaw of such size and so placed as to injure it materially, shall be rejected.

210. *Welding of castings.*—No electric or other welding or patching of defects in castings shall be done, unless authorized by the Engineer. Any such welding or patching done without the Engineer's consent shall cause the rejection of the casting.

211. *Physical tests.*—Test pieces taken from coupons on the annealed castings shall show an ultimate strength of not less than 65,000 lbs. per square inch, an elastic limit of at least 35,000 pounds per square inch, and an elongation of not less than 20 per cent in 2 inches. They shall bend without cracking 120 degrees around a rod twice the thickness of the test piece.

212. *Shape and finish.*—All steel castings must be true to the drawings, with smooth surfaces, and all re-entrant angles must be neatly filleted. They must be placed exactly true and smooth where the drawings require, and all holes for bolts must be drilled accurately to metal templets. Bolt holes in castings shall be 'spot-faced' wherever required by the Engineer.

213. *Cleaning.*—All cores of castings shall be thoroughly removed and the mould sand thoroughly cleaned from the surfaces.

CABLES, SUSPENDERS AND HAND ROPES.

214. *Steel for wire.*—All steel for wire for the cables, suspenders and hand ropes shall be made throughout in an open-hearth furnace, lined with silica.

The wire for serving the cables shall be made of Norway iron of a quality approved by the Engineer.

215. *Stock.*—The melting stock used for wire steel shall consist of pig iron to the extent of not less than 45 per cent of the total charge, together with other suitable melting stock. None of the pig iron and none of the other melting stock shall contain more than ·03 of one per cent of phosphorus or ·03 of one per cent of sulphur.

216. Reduction of carbon.—The use of iron ore for the reduction of carbon in the furnace charge will be allowed according to the usual and good practice.

217. *Recarburization.*—The recarburization of steel is essential and the addition of manganese and carbon shall be accomplished by the use of ferro-manganese or spiegeleisen only, and shall be performed carefully, in a manner most likely, in the opinion of the Engineer, to give good results.

218. *Decarburization.*—During the reduction of the steel in the open-hearth furnace, it shall not be decarburized below ·20 of one per cent.

219. *Chemical requirements.*—The ladle tests of the steel shall conform to the following chemical requirements:—

Carbon, not to exceed	·85	of one per cent.
Manganese, not to exceed	·55	" "
Silicon, not to exceed	·20	" "
Phosphorus, not to exceed	·04	" "
Sulphur, not to exceed	·035	" "
Copper, not to exceed	·02	" "

220. *Ingots.*—The finished steel shall be cast in ingots of such size, weight and shape and so poured as, in the judgment of the Engineer, to eliminate to the greatest degree piping and harmful segregation. All surface defects shall be removed, and enough of the top of each ingot discarded to insure sound material. This discard must represent not less than 30 per cent of the weight of the ingot, and shall extend as much farther as may be necessary to secure freedom from pipings and injurious segregation.

221. *Billets.*—The wire billets rolled from these ingots shall be free from cracks and seams, and shall be straight and have square sections, suitable for rolling into wire rods. The billets shall be cut into uniform lengths, to weigh not less than 350 pounds each, and surface defects shall be cut out.

222. *Physical requirements.*—The wire for cables, hand ropes and suspenders shall have an ultimate strength of not less than 215,000 pounds per square inch before galvanizing, and an elongation of not less than 2 per cent in 12 inches of observed length, the stretch to be measured while the specimen is in the testing machine. The bright wire shall be capable of coiling cold around a rod of 1½ times its own diameter without sign of fracture. The cable wire before galvanizing shall not vary in gauge more than 3-1000 of an inch. It shall be drawn on large size blocks, and finished in single lengths of not less than 3,000 feet, and shall be drawn as straight as possible without any kinks or sharp bends. After galvanizing, the steel wire shall have an ultimate strength of not less than 200,000 pounds per square inch of gross section.

223. *Wire straightening.*—No machine straightening of wire shall be allowed. The wire must not from tendency to coil, cause trouble or delay during any of the operations, from the splicing and winding on reels to the completion of stringing into cable strands.

224. *Cable shield.*—While reeling the wires on large reels after galvanizing and splicing, the wire shall be run through a bath of cable shield so that they will be thoroughly coated therewith.

225. *Number of tests of wire.*—Sufficient physical tests on the finished coils of wire shall be made at the mill to satisfy the Engineer that the wire meets the specified requirements; but tests may be taken from both ends of each coil, in order to insure the specified physical requirements. Tests on pieces of wire not less than twelve feet long shall also be made.

226. *Field splices.*—All field splicing of wire shall be done with thread cutting dies of approved pattern and in first-class condition, and shall be done by skilled workmen.

227. *Strength of wire for ropes.*—The wire for the cables, cable serving, hand ropes and suspenders shall be galvanized and inspected as to the following requirements for galvanized wire; when galvanized, it shall gauge not more than 5-1000 of an inch larger than the bright wire. The galvanized wire shall have an elongation of 4 per cent, in twelve inches of length, as observed under tension, and shall bend continuously around a mandrel four (4) times the diameter of the wire without breaking or peeling off any of the zinc coating.

228. *Zinc for galvanizing.*—The galvanizing shall consist of a coat of zinc 99.75 per cent pure, containing not more than .03 of one per cent of iron. It shall be applied in the molten state in an even and uniform manner.

The zinc coating shall be so applied that it will adhere firmly to the surface of the wire and form a continuous coating of uniform thickness.

229. *Test for galvanizing.*—All specimens of galvanized wire shall be capable of withstanding the following test:

The sample shall be immersed in a standard solution of copper sulphate for one minute, immediately thoroughly washed in water and wiped dry. This process shall be repeated. If, after the fourth immersion there should be a copper-coloured deposit on the sample, or the zinc should have been removed, the sample shall be rejected.

230. *Solution for test.*—The standard solution of copper sulphate shall consist of a solution of commercial copper sulphate crystals in water. This solution shall have a specific gravity of 1.185 at seventy (70°) Fahrenreit. While a sample is being tested, the temperature of the standard solution shall at no time be less than sixty (60°) degrees Fahrenheit nor more than 65 Fahrenheit. While galvanizing the cable wire shall be coiled on blocks not less than four (4) feet in diameter.

GENERAL PROVISIONS AS TO STEEL.

231. *Manufacturers of steel.*—All steel for any purpose in this bridge shall be made by manufacturers of established reputation for the kind and character of steel specified.

232. *Size of billets.*—All finished material shall, when practicable, be rolled or forged from billets which are of a size to reduce at least sixteen times in area in forming the finished shapes.

233. *Treatment of furnace charge.*—No lime or other basic material other than iron ore shall be added to the furnace charge of acid open-hearth steel during any stage of the melting or pouring of the steel.

234. *Acceptance not final.*—Acceptance of any material at the mill, foundry or elsewhere, before acceptance of the bridge by the Minister, will not be considered as final.

235. *Identification.*—No steel will be accepted unless made especially for this work; and when so made, it shall be subject to a system of identification approved by the Engineer, and, furthermore, such especially made steel shall be handled by itself or isolated in any manner required by the Engineer, to prevent the possibility of its becoming mixed with other kinds of steel.

236. *Presence of inspector.*—No steel shall be made or cast, nor shall any material be rolled unless the Engineer or inspector has been notified in time to be present.

237. *Orders to manufacturers direct.*—All orders for steel shall be placed by the Contractor directly with the manufacturer, and all such orders shall have embodied in them the full specified requirements for the same, and as many carbon or hektograph copies of all orders for steel shall be furnished to the Engineer, at the time of placing such orders with the manufacturer, as he may require.

INSPECTION AND TESTING.

238. *Representative of the Chief Engineer.*—The Chief Engineer, at the expense of the Minister, may appoint a representative whose duty it will be to see that the inspection is satisfactorily performed.

239. *Chemist.*—The Chief Engineer, at the expense of the Minister, may appoint a chemist who will check tests made by the Contractor, said chemist to be provided by the Contractor with an office and all apparatus and chemicals necessary to perform said tests.

240. *Weekly reports.*—Weekly reports in full detail, including reports of chemical analyses shall be sent to the Chief Engineer, not later than the end of the week succeeding the week in which such tests were made.

241. *Results of tests.*—The results of physical tests must be given in pounds per square inch.

242. *Inspection.*—All stock and materials used in the manufacture of the steel and all operations at the furnaces, rolls and elsewhere about the establishments where the steel is made or manufactured, shall be subject to the examination, approval and acceptance of the inspector, who shall have free access to all records appertaining to the manufacture of the steel, from the beginning until its final acceptance. Ingots, &c., shall be so marked that the steel and heats can be identified at any time during the process of manufacture. The marks must be stamped on the hot material.

243. *Chemical analysis, how made.*—Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese (and nickel in the case of nickel steel) shall be made by the manufacturer, from one or more test ingots taken during the casting of each melt of steel, said test or tests to be fairly representative of each melt of steel. Two correct copies on such analyses shall be furnished to the inspector. Check analysis shall be made of the finished product on drillings from the tensile or bending test pieces of the rolled or forged material, and taken as directed by the Chief Engineer or chemist appointed by him.

244. *Test pieces, plates, shapes and bars.*—Specimens for determining the tensile strength, elastic limit, per cent of elongation and per cent of reduction, of plates, shapes, and bars, shall be taken from the rolled material, without annealing, unless the material itself is annealed, and specimens for bending shall be taken in the same way.

245. *Copies of records.*—The Contractor shall furnish to the inspector copies of all records and furnish all facilities necessary to enable him to readily keep track of the steel and identify any heat at any stage during the process of manufacture. Two copies of all mill orders shall be furnished to the inspector besides the copy sent to the Engineer.

246. *Ultimate strength required.*—There shall be at least three tensile tests and two bending tests from each melt of steel.

In case the ultimate strength falls outside of the specified limits by less than one thousand (1,000) pounds, all other requirements being filled, or in case the elastic limit falls below the specified minimum by less than 1,000 lbs. all other requirements being filled, then two more tests may be taken from material of same thickness for each test thus failing, and if both such re-tests fill the requirements, the material will be accepted.

247. *Number of tests.*—If the material rolled from a melt varies in thickness by $\frac{3}{8}$ inch or more for plates and shapes, or by $\frac{1}{2}$ inch or more for bars, a test shall be made from the thickest, and also from the thinnest material rolled from the melt.

Separate test shall be made for (1st) plates, (2nd) shapes, and (3rd) bars.

248. *Check of analysis.*—Check analyses of the finished steel or wire billets may be made at any time when required by the Engineer. These check analyses shall not

show a variation of more than 25 per cent above the ladle analysis for phosphorus or more than 50 per cent above the ladle analysis for sulphur. These check analyses are to be

249. *Additional tests.*—Additional tests shall be made if the melt is rolled at different places.

250. *Number of tests from steel castings.*—The number of coupons required on steel castings will depend upon the size and importance of the castings. They must be of such number as will insure uniformity as well as quality of the castings, and their number and location shall be determined by the inspector. Coupons must not be detached from castings until after they are annealed.

251. *Forms of test pieces.*—Test pieces will generally be of the form recommended by the American Society for Testing Materials.

252. *Contractor to furnish test pieces.*—The Contractor shall at his own expense furnish all test pieces of such shape and perform such tests thereon under the supervision of the inspector as required by the Engineer.

253. *Rivet rods.*—Specimens of rivet rods shall be cut from the finished rods without further preparation.

254. *Pins.*—Test specimens shall be cut at a depth from the cylindrical surface equal to one-half the radius of the pin. All forged pins shall be annealed. Pins shall be tested individually (tensile test), but may be forged or rolled, as the case may be, in multiples, in which case two tensile tests shall be taken, one from each end of the bar. Each pin shall be so marked as to be easily identified. Tensile tests may be the usual 8-inch specimens, or may be 2 inches (2″) between measuring points and $\frac{1}{2}$ inch diameter, in which case the minimum elongation in 2 inches shall be

$$\frac{1{,}800{,}000}{\text{ultimate strength.}}$$

255. *Office room for inspectors.*—The Contractor shall furnish for the use of the inspectors a suitably equipped office at the mills and at the shops.

256. *Facilities for inspectors.*—The inspector shall be on hand to make all examinations and tests promptly. All facilities necessary must be furnished by the Contractor to the inspector to make these examinations and tests thorough and conclusive.

No material shall be inspected on the hot beds or at night, or outside in bad weather, or in dark places and the Contractor shall furnish all men and appliances necessary to handle and turn over all materials, to allow of a thorough inspection being made.

257. *Rejection.*—Any piece of material which, through oversight or otherwise has passed the inspector, may be rejected at any stage of the work, if found defective or contrary to these specifications.

258. *Stamping melt number.*—Every plate or shape shall be distinctly stamped near the middle with the melt number, which shall be surrounded with a heavy circle of white paint. Pin steel shall be stamped on ends. Rivet steel may be shipped wired in bundles with the melt number attached.

FULL SIZE TESTS.

259. *Tests required.*—The manufacturer shall at his own expense furnish, build and test the following number of samples of wire suspenders and full size eyebars:

260. *Wire suspenders.*—Two suspenders shall be tested similar in every respect to the suspenders used, except that they shall be made of the maximum length that the longest existing testing machine will admit.

Their stretch shall be measured under increments of load of 10,000 lbs. until destruction.

The strands, as well as the shoes, shall stand without breaking, a load of 150,000 lbs. per square inch of wire in the strands.

These tests shall be made before the suspenders used in the bridge are manufactured; and if the final strength of 150,000 lbs. per square inch is not obtained in the shoes or strands, the manufacturer shall, at his own expense, furnish, build and test other samples until two consecutive tests show the required strength.

261. *Eyebars.*—Tests of full size eyebars shall be made as follows: From every lot of forty (40) eyebars, not rejected for surface defects, one bar shall be selected by the inspector. All bars of each lot must have had as far as possible the same treatment and have been finished at about the same time.

Each lot must be kept separate and distinct until the full size tests representing them have been made and the bars accepted.

The bars will be required to meet the specifications and to break in the body. In the event of failure to do so, two additional bars shall be selected by the Engineer and tested. If either one of these bars break at the head and fails to develop 5 per cent elongation in 18 feet and 48,000 lbs. elastic limit, or breaks in the body and fails to meet the requirements of the specifications, the entire lot of bars or the entire heat shall be rejected.

Full size test of nickel steel eyebars, after annealing, must meet the following requirements:

Yield point (minimum) 47,000 lbs. per sq. in.
Ultimate strength, 80,000 to 100,000 lbs. per sq. in.
Elongation in 18 feet (minimum), 10 per cent.
Reduction of area (minimum), 25 per cent.

Full size tests of carbon steel eyebars, after annealing must meet the following requirements:

Ultimate strength, 56,000 to 70,000 lbs. per sq. in.
Minimum elastic limit, 30,000 lbs. per. sq. in.
Minimum elongation in 18 feet, 12 per cent.

262. *Model tests.*—In order to finally determine the allowable unit stresses on sections and details of truss members, test models of such members, reduced in scale, also splices and other details, shall be tested by the Contractor under the direction of the Board, and in accordance with the drawings to be furnished by the Board, and in such numbers as it may designate.

The test models of truss members shall be of the maximum dimensions which the largest testing machine available will test.

In tension members, one leaf may represent the member.

Tension tests of riveted tension members are expected to meet the following minimum requirements:—

Carbon steel, elastic limit, 30,000 lbs. per sy. in. net section; ultimate strength, 55,000 lbs. per sq. in. net section.

Nickel steel, elastic limit, 45,000 lbs. per sq. in. net section; ultimate strength, 77,000 lbs. per sq. in. net section.

Nickel steel compression tests are expected to develop not less than the following values as determined by the tests made by the Board:

Elastic limit, 41,000 lbs. per sq. in.
Ultimate strength, 52,000 lbs. per sq. in.

Carbon steel compression tests are expected to develop not less than the following values:

Elastic limit, 28,000 lbs. per sq. in.

Ultimate strength, 36,000 lbs. per sq. in.

In case the tests are unsatisfactory, the Board may require either changes in the design and further tests or an increase in section or both.

The Contractor will be paid the actual cost of all test pieces under this paragraph, together with the cost of testing same. The test pieces shall become the property of the Minister, but if required to do so, the Contractor shall dispose of the scrap, deducting a fair value therefor from the cost of such tests.

263. *Use of testing machines.*—The Contractor shall furnish free of charge to the Minister, the use of testing machines for all specimen tests and eyebars. Eyebars and built members shall be tested in the strongest machine available.

PAINTING.

264. *Paint.*—The paint shall be made of pigment, thoroughly mixed in boiled linseed oil, without spirits of turpentine.

265. *Dryer.*—Dryer shall be made of linseed oil, boiled with lead or manganese, dissolved in spirits of turpentine.

266. *Use of dryer.*—No dryer will be added to the paint unless authorized by the Engineer, and the quantity of dryer to be added in every particular case shall be given by the Engineer in writing, but shall in no case be more than three per cent (3%), with the exception of the paint used on materials before riveting, where the Engineer may allow a larger percentage to be used.

The permission to use dryer must be obtained from the Engineer three or four days in advance in order to allow him to have the necessary tests made to determine the time required for drying; one without dryer, one with 1½ per cent, and one with 3 per cent dryer added.

267. *Oil.*—The oil shall be pure and clear linseed oil, boiled with lead or manganese to a minimum specific gravity of 0·0939.

The boiled linseed oil must be absolutely pure, containing no material volatile at 212 degrees Fahrenheit in a current of hydrogen; shall not contain any resin or manganese or rosinate of manganese, and shall be perfectly clear on receipt and no deposit should form on standing, provided the oil is kept at a temperature above 45 degrees Fahrenheit. The film left after flowing the oil over glass and allowing it to drain in a vertical position must dry to the touch after 24 hours.

268. *Delivery of oil.*—The linseed oil shall be delivered in strong, tight, well made white oak casks, hooped with iron, each having a capacity not exceeding 50 gallons.

269. *Pigment.*—The pigment shall be pure red lead with addition of lamp black not to exceed four (4) ounces of lamp black to thirty (30) pounds of red lead for the shop paint.

Peroxide of iron shall be used for the paint before riveting. The pigment and colour to be used after erection shall be determined later by the Minister.

270. *Red lead.*—The red lead must be strictly pure, and shall contain at least 90 per cent of true red lead (of the composition Pb. 3. O4) the total amount of lead present shall not be less than 89 per cent, of which not more than 1-10 of one per cent shall be present as metallic lead. The colour shall be a clean and pure tint. The red lead shall be of the fineness that when washed with water through No. 19 silk bolting cloth not more than one per cent shall be left on the screen.

271. *Delivery of red lead.*—The red lead shall be delivered in suitable 100-pound packages.

272. *Paint to be kept in original packages.*—All paint material to be delivered, inspected and sampled in the original packages.

273. *Inspection.*—Before acceptance the above specified materials shall be inspected; samples of each lot delivered will be taken at random, the samples well mixed together in a clean vessel, and the samples for test taken from this mixture. If it is found that this sample does not conform to the requirements of the specifications, the whole delivery it represents will be rejected, and shall be removed by the Contractor at his own expense.

274. *Chemist.*—Check tests of all paint materials shall be made by a chemist appointed by the Chief Engineer and paid by the Minister. The chemist shall be provided by the Contractor with an office, and all apparatus and chemicals necessary to perform said tests.

275. *Storage of paints and oils.*—The oils, paints, pigment, &c., used in connection with this contract must be kept at the shops in a storage room separate from that in which any other paints are kept.

276. *Material not to be exposed to weather.*—All rolled metal work shall be kept under cover as far as practicable from the time it is rolled until it is painted, and no material which has been punched or planed shall thereafter be exposed to the weather until it has been painted.

All material arriving from the mills shall be unloaded without delay, and protected from rust by being stored under cover or by the application of a coat of pure boiled linseed oil.

277. *Cleaning.*—Before painting at the shop, all material shall be thoroughly cleaned of scale, rust, grease, dirt, chips and borings with steel scrapers and brushes or by other efficient method. Benzine shall also be used wherever required by the inspector for this purpose.

278. *Painting.*—The paint shall contain as much pigment as possible, be kept well mixed before and during painting and applied with brushes, and be well worked into all joints and surfaces. Wherever the paint runs or streaks a fresh coat shall be applied.

279. *Number of coats.*—In riveted work, the surfaces coming in contact shall each be painted before being bolted together, and the paint must be dry before assembling.

After the pieces are finished in the shop, they shall be given one good coat of paint.

Pieces and parts which are not accessible for painting after erection, including tops of stringers, eyebar heads, ends of posts and chords, &c., shall be given two coats of paint before leaving the shop and one extra coat before being erected in place.

The cable shield shall be thoroughly removed from the surface of the wire suspenders, which shall then be given two coats of red lead.

Machine finished surfaces, except faced ends of members, which shall be painted, shall be coated with white lead and tallow before leaving the shops.

All the painting before shipment specified above shall be done under cover and with metal dry and free from frost. The pieces must remain under cover until the paint is perfectly dry.

The heads of all field rivets shall be given a coat of red lead within three days after they are driven.

After the steel is erected it shall be thoroughly cleaned and any parts where the paint has been scratched off or removed, shall be painted with red lead. The whole work shall then be given two addditional coats as determined later by the Minister.

Painting shall be done only in dry weather and applied only on surfaces dry and free from frost.

Revised March 13, 1911.

LIST OF DRAWINGS ATTACHED.

Plan No. 1.—General elevation of bridge.
" 2.—Stress sheet of anchor arm.
" 3.—Stress sheet of cantilever arm.
" 4.—Stress sheet of suspended span.

Name.	Address.	When Received.	Design No.	No. of lbs.	Price per lb.	Remarks.
(A) Maschinenfabrick, Augsberg-Nurnburg, A.G.	Gustavsburg, Bei Marig.	3.30 p.m. Sept. 30, '10.	Board's design No. 1	145,404,000	9·36	Accepted cheque for $500,000 on the Canadian Bank of Commerce, payable to Minister of Railways and Canals, and signed by C. Cambie, Asst. Mgr.
			Flooring item 4.		$75,000 00	
			" No. 2	135,821,000	9·36	
			Lump sum		$560,000 00	
			Flooring item 3.		$75,000 00	
			" No. 4	141,576,000	9·43	
			Flooring item 4.		$75,000 00	
			" No. 5	132,307,000	9·43	
			Lump sum, item 3.		$560,000 00	
			Flooring item 4.		$75,000 00	
			M. A. N.'s design	131,750,000	9·27	
			Flooring item 4.		$75,000 00	
(B) Pennsylvania Steel Co.	Philadelphia, U.S.	5.30 p.m. Sept. 30.	Based on Board's design No. 1; based on modification.		$0·081	Accepted cheque for $500,000 on Bank of Montreal, payable to Minister of Railways and Canals, and signed by Pennsylvania Steel Co., per Edward N. Smith.
			Lump sum, item 4.		$100,000 00	
			Based on modification of Board's design 2, scheme B.		$0·083	
			Lump sum, item 4.		$100,000 00	
			Based on modification of Board's design 2, scheme A.		$0·0849	
			Lump sum, item 4.		$100,000 00	
			Based on modification of Board's design 3, scheme B.		$0·0825	
			Lump sum, item 4.		$100,000 00	
			Based on modification of design, scheme A 3.		$0·0844	
			Lump sum, item 4.		$100,000 00	
			Based on modification of Board's design 4.		$0·0814	
			Lump sum, item 4.		$100,000 00	
			Board's design, scheme A 5.		$0·0859	
			Lump sum, item 4.		$100,000 00	
			Board's design, scheme B 5.		$0·084	
			Lump sum, item 4.		$100,000 00	
			Board's specification; scheme A 6.		$0·0851	
			Lump sum, item 4.		$100,000 00	
			Scheme B 6		$0·0835	
			Lump sum, item 4.		$100,000 00	
			Contractor's plan	145,385,000	$0·0941	
			Lump sum, item 4.		$100,000 00	
(C) The British Empire Bridge Co., Ltd.	Can. Express building, Montreal.	11.06 p.m. Sept. 30, '10.	Board's plan, scheme 1	143,924,000	7·62	Accepted cheque for $500,000 on the Bank of Montreal, payable to Minister of Railways and Canals, and signed Manager and Accountant.
			Lump sum, item 4.		$105,000 00	
			" " 2	134,344,000	7·62	
			Lump sum, item 3.		$595,000 00	
			" 4.		$105,000 00	
			Scheme 2, alternative plan.	134,344,000	7·62	

				Lump sum, item 3.	$150,000 00	
				" 4.	$105,000 00	
			Scheme 4	138,866,000	7·62	
				Lump sum, item 4.	$105,000 00	
			" 5	129,597,000	7·62	
				Lump sum, item 3.	$595,000 00	
				" 4.	$105,000 00	
			" 5	129,597,000	7·62	
				Lump sum, item 3.	$300,000 00	
				" 4.	$105,000 00	
(D) St. Lawrence Bridge Co., Ltd.	Room 2, Windsor Hotel, Montreal.	11.30 a.m. Oct. 1, '10.	Board's plan, design 1	. . . . .	10·90	No. 1. One accepted cheque for $250,000 on the Bank of Montreal, payable to the order of the St. Lawrence Bridge Co., Ltd., and signed Dominion Bridge Co., Ltd.
				Lump sum, item 4.	$75,000 00	
			Design 2	134,244,000	10·97	
				Lump sum, iten. 4.	$75,000 00	
			" 3	136,778,000	10·94	
				Lump sum, item 4.	$75,000 00	
			" 4	138,866,000	10·95	
				Lump sum, item 4.	$75,000 00	No. 2. One accepted cheque for $250,000 on the Canadian Bank of Commerce, payable to St. Lawrence Bridge Co., Ltd., and signed by B. L. Colburn, Treas. of the Can. Bridge Co., Ltd.
			" 5	129,597,000	11·00	
				Lump sum, item 4.	$75,000 00	
			" 6	131,969,000	10·97	
				Lump sum, item 4.	$75,000 00	
			Contractor's plan, design A.	130,600,000	9·20	
			Contractor's plan, design B.	136,000,000	8·65	
			Contractor's plan, design C.	125,500,000	9·58	
			Contractor's plan, design M.	111,000,000	10·10	
			Contractor's plan, design N.	115,000,000	9·91	
			Design X, railway service only.	98,600,000	9·22	
			Design Y, railway service only.	92,060,000	9·98	

(E) Letter from Mr. George Goodwin, not a tender.

Prepaid in the presence of the Minister of Railways and Canals.

(Sd.) L. K. JONES.
C. W. ROSS.

OTTAWA, Oct. 5th, 1910.

DEPARTMENT OF RAILWAYS AND CANALS, CANADA.

QUEBEC BRIDGE.—TENDERS FOR SUPERSTRUCTURE.

Notice to bridge builders.

Contractors for bridge superstructure are invited to visit the office of the Board of Engineers in the Canadian Express Building, Montreal, Canada, after January 3, 1910, where information may be had to enable them to prepare bids for the superstructure of a 1,758 feet span bridge 88 feet in width.

Bids will be received on the specification and for the design shown on the plans as prepared by the Board.

The Contractor is invited to submit alternative designs which must conform to the conditions laid down in the general specification.

By order,

L. K. JONES,

Secretary.

Department of Railways and Canals,
Ottawa, November 24, 1909.

DEPARTMENT OF RAILWAYS AND CANALS.

QUEBEC BRIDGE.—TENDERS FOR SUPERSTRUCTURE. NOTICE TO CONTRACTORS.

Sealed tenders addressed to the undersigned and endorsed 'Tenders for Quebec Bridge Superstructure,' will be received at this office until 12 o'clock noon, not later than September 1, 1910, for the superstructure of a bridge across the St. Lawrence River near the City of Quebec.

Plans and specifications may be seen and forms of tenders obtained on and after July 1, 1910, at the office of the Quebec Bridge Board of Engineers, Canadian Express Building, Montreal, and at the Department of Railways and Canals, Ottawa.

Parties tendering will be required to accept the fair wages schedule prepared or to be prepared by the Department of Labour, which schedule will form part of the contract.

Contractors are requested to bear in mind that tenders will not be considered, unless made strictly in accordance with the printed forms, and in the case of firms, unless there are attached the actual signature, the nature of the occupation, and place of residence of each member of the firm.

An accepted bank cheque for the sum of $500,000 made payable to the order of the Minister of Railways and Canals if Canada must accompany each tender, which sum will be forfeited if the party tendering declines entering into contract for the work at the rates stated in the offer submitted and in accordance with the terms stated in the form of contract accompanying the specifications.

Cheques thus sent in will be returned to the respective contractors whose tenders are not accepted.

The lowest or any tender not necessarily accepted.

L. K. JONES,

Secretary.

Department of Railways and Canals,
Ottawa, 17th June, 1910.

(Newspapers inserting this advertisement without authority from the Department will not be paid for it.)

SESSIONAL PAPER No. 104

DEPARTMENT OF RAILWAYS AND CANALS.

QUEBEC BRIDGE.—TENDERS FOR SUPERSTRUCTURE. NOTICE TO CONTRACTORS.

Extension of Time for Receiving Tenders.

The time for receiving tenders for the superstructure for the Quebec bridge advertised to be received up to the 1st of September, 1910, is hereby extended for one month, viz.: up to October 1, 1910.

By order,

L. K. JONES,

Secretary.

DEPARTMENT OF RAILWAYS AND CANALS,
Ottawa, 9th August, 1910.

(Newspapers inserting this advertisement without authority from the Department will not be paid for it.)

Enclose plans and specifications, also tenders, draft form of contract, in duplicate attached.

March 28, 1911.

The undersigned has the honour to submit to Your Excellency in Council the following statement with regard to the steps taken for the re-construction of the collapsed Quebec bridge over the river St. Lawrence, together with a recommendation for the letting of the contract for the superstructure.

It has been thought well, in view of the importance of the subject, and the difficulties that have arisen in dealing with it, that this statement should be a fairly comprehensive one.

The collapse of the bridge occurred on August 29, 1907, while under construction by the Quebec Bridge and Railway Company. In pursuance of the Act of 1908, Chap. 59, and an Order in Council dated August 17, 1908, the whole undertaking, assets, property and franchises of the Quebec Bridge and Railway Company were assumed by the Crown on December 1, 1908, the deed of transfer being dated October 15, 1908.

By an Order in Council of August 17, 1908, a special board of engineers was constituted for the purpose of reconstruction of the bridge. The members of the Board were Mr. H. E. Vautelet, C.E., M.C.S.C.E., chairman and chief engineer; Mr. Ralph Modjeski, M.I.C.E., M.A.S.C.E., of Chicago, Ill., U.S.A., and Mr. Maurice Fitzmaurice, C.M.G., M.I.C.E., chief engineer of the London county council, England.

The Board, so constituted, were to make a full examination and prepare a scheme for reconstruction, with a design and specifications, submitting the same to the department for its action thereon. The Board were empowered, in the event of difference of opinion arising, to call in not more than two engineers to advise as to points of difference arising. The entire responsibility for the design and for the work of reconstruction was to rest with the Board.

Suitable offices were obtained and a staff of men, selected by the Board, was, from time to time, appointed; their salaries being approved by Orders in Council.

Under date of January 10, 1910, a contract was made with Messrs. M. P. and J. T. Davis for the piers and abutments of the superstructure. On April 9, 1910, a contract was entered into with Messrs. C. Koenig & Company for the removal of the debris of the old bridge, and on May 11, 1910, a contract was made with the Phœnix Bridge Company for the removal of the approach spans.

Towards the close of the year 1909, the Board had made such progress that on November 24 of that year the department was in a position to invite, by newspaper advertisement, intending bidders, as a preliminary step, to visit the offices of the Board of Engineers in Montreal, where information might be had to enable them to prepare tenders. This advertisement, while stating that tenders would be received for a structure on the specifications and according to the design shown on the plans as prepared by the Board, added an invitation to tenderers to submit alternative designs, conforming, however, to the condition laid down in the Board's specifications.

This admission of alternative designs was the result of a difference of opinion amongst the members of the Board as to the design prepared, and on account of the desire to secure the best possible design; the Board, therefore, considered it advisable that tenders should be called for on the official plan, prepared by their chairman and Chief Engineer, with the understanding that tenderers should be allowed to present any other design they chose, and that these alternative designs would be fully considered. The Board unanimously adopted a resolution on May 2, 1910, as follows:—

> 'It is resolved that the plans and specifications for a cantilever design now completed be approved and submitted to the Minister for tenders and that in the event of a better plan being submitted by any of the bidders same shall be adopted.'

Tenders were formerly called for by the department by newspaper advertisement, dated June 17, 1910. The tenders were to be received up to September 1, 1910, a date which was subsequently extended, by newspaper advertisement, up to October 1, 1910.

In response, tenders were received from the following parties:—

The Pennsylvania Steel Company, Philadelphia, U.S.A.

Maschinenfabrik Augsburg-Nurnburg, A. G. Gustavsburg, Germany.

The British Empire Bridge Company, Limited, Montreal and The St. Lawrence Bridge Company, Limited, Montreal.

These tenders were submitted to the Board, the personnel of which had been changed by the retirement of Mr. Fitzmaurice, and the appointment in his stead, by Order in Council of October 5, 1910, of Mr. Charles Macdonald, M.A.S.C.E., M.I.C.E., the resignation and the appointment to date from September 28, 1910.

Under date the 26th of October, 1910, the Board sent in a report on the tenders received, stating that 35 different propositions had been submitted, of which the Board had eliminated, as not acceptable, all but the following:—

1. Design No. V of the Board, with short shore arms and floating erection of the suspended span on high staging, tenders on which were submitted by all four firms.

2. Design 'A' of the St. Lawrence Bridge Company, being different in outline from the Board's design and having the top chords built of nickel steel plates throughout.

3. Design 'B' of the St. Lawrence Bridge Company, similar in all respects to design 'A', except that the top chords of the anchor arms are built of carbon steel.

4. Design 'C' of the St. Lawrence Bridge Company, similar in all respects to 'B', with the exception of the top chords, which are designed with eyebars, instead of plates.

They go on to observe that, classified for cost, those are as follows:—

1.	British Empire Bridge Co., Board's design V.	$11,025,566
2.	Pennsylvania Steel Co., Board's design V.	11,686,751
3.	St. Lawrence Bridge Co., design 'B'.	11,957,500
4.	" " " 'A'.	12,153,500
5.	" " " 'C'.	12,216,400
6.	Maschinenfabrik Augs-Nurn, Board's design V. . .	13,230,050
7.	St. Lawrence Bridge Co., Board's design V.	14,867,170

They add that the cost, as per specifications, may be increased by 2% and includes an amount of $118,500 to be paid for increased quantities of masonry in the anchor and short piers. They express the opinion that it is possible to construct a bridge in accordance with either of the tenders received upon the Board's design No. V which would make a satisfactory structure; also, that it is possible to construct a bridge in accordance with the designs 'A', 'B' and 'C' submitted by the St. Lawrence Bridge Company, which would make a satisfactory structure, providing that plans, details and material were made in accordance with the specifications of the Board, including modifications allowed to other bidders.

This report was signed by all three members of the Board.

In view of the fact that no definite recommendation was made in this report as to the acceptance of any individual tender, the undersigned wrote the Board on the 1st of November, 1910, and asked that they make a recommendation as to what tender, under all the circumstances, should be accepted.

To this a reply was received from two members of the Board, Messrs. Macdonald and Modjeski, under date November 3. They state that on close investigation of the alternative designs it was found that one, presented by the St. Lawrence Bridge Company, while designed on the single intersection principle, in a very practical way met all the demands that a portion of the Board had in their minds when they favoured the double intersection principle. They observe further that a bridge could undoubtedly be constructed on the official design, and once erected would be a substantial structure; but that they are of the opinion that design 'B' of the St. Lawrence Bridge Company, in addition to providing for a satisfactory bridge offers features which simplify the erection and minimize the risk to both life and property entailed in a work of such magnitude, which they consider of paramount importance. For this, and other reasons, they recommend the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B'.

This report not having been signed by Mr. Vautelet, on communication with him, he wrote the undersigned, on December 10, 1910, dealing with the several grounds taken by his colleagues in recommending the acceptance of design 'B' of the St. Lawrence Bridge Company, stating that neither it, nor the other designs by the Company, comply with the requirements that the Board have expressed in the specifications, and should not, therefore, be considered. He adds that the Board's design complies with all the requirements, both of the Board and of the Department, and that he knows no technical reason why either of the four tenders on this design should not be accepted. He states that he could not join in the recommendation of his colleagues for the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B'.

Under these circumstances, it being clear that a serious difference had arisen, Messrs. M. J. Butler, C.M.G., M.C.S.C.E., and Henry W. Hodge, M.A.S.C.E., M.I.C.E., were called in to advise the Board in the matter, and under date of February 8, 1911, a report was sent in by the Board, signed by Mr. Macdonald, Chairman, *Pro. tem.*, in the absence of Mr. Vautelet, who was absent through illness, Mr. Modjeski, Mr. Hodge, and Mr. Butler. This report is as follows:—

BOARD OF ENGINEERS, QUEBEC BRIDGE,

MONTREAL, February 8, 1911.

SIR,—In accordance with your letter of January 30, appointing Messrs. M. J. Butler and Henry W. Hodge to advise with the Board of Engineers, Quebec Bridge, on the points of difference that have arisen in that Board, we have the honour to report as follows:

The Board, with the exception of Mr. Vautelet, who is detained in his home by illness, met with the advisory engineers on February 6, and have been in session for the past three days, Mr. Macdonald acting as temporary chairman.

We have examined the various tenders and general designs and the advisory engineers have read the written opinions of the members of the Board, and in addition thereto, the opinion of Mr. Vautelet, as expressed in his letter to them dated February 2. They have also considered the verbal arguments of each member of the Board, adjourning to Mr. Vautelet's residence for the purpose of conferring with him.

The only point of difference in the Board is as to which specific design and tender should be recommended for acceptance; the Board being divided between the official design and the design of the St. Lawrence Bridge Company.

None of the tenders on either of these two designs were made without requiring modifications of the specifications, so that such alterations must be considered if any of these tenders are to be accepted.

The advisory engineers have not considered it within the province of their appointment to examine closely into the details of the two above mentioned designs, and all of us are of the opinion that consideration of details is a matter that must be carefully studied and worked out in the light of further tests yet to be made by the Board of Engineers.

From our examination of the two above mentioned general designs, we, the undersigned, agree that the design of the St. Lawrence Bridge Company is preferable for the following reasons:

(*a*) The type of design offers greater safety to life and property during erection, as well as economy and rapidity in construction.

(*b*) The design contains the minimum number of secondary members, and requires few, if any, temporary members during erection.

(*c*) The system of triangulation by dividing the web stresses reduces the members to more practical sections and simplifies the details of connections.

(*d*) The design economizes material as shown by the calculated weights of the two designs.

(*e*) The general appearance of the structure is, in our opinion, improved.

We feel that in a work of such magnitude the question of design is of the first importance and for the reasons given above we recommend the acceptance of design 'B' of the St. Lawrence Bridge Company, subject to certain modifications in general outline and detail, which we deem advisable and which will result in economy, and further improvement in appearance. The modifications of their design we have in mind will reduce the cost of the work by, at least, four dollars per ton, and we recommend the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B' at a price not exceeding 8·45 cents per pound (amounting in the calculated weight to $11,246,100) and at a corresponding reduction on their other pound prices, if the Board should decide to accept any features of their alternative tenders.

The lowest tender of the British Empire Bridge Company, when the additional price they give for complying with the splices required by the official design is added, amounts to $11,320,720.

While not called for by the advertisement, the St. Lawrence Bridge Company submitted, among their tenders, one omitting the roadways, which at the reduction in their round price above mentioned, shows a cost of $8,650,000 on the figured weight, and we think this should be called to your attention, as the highways can

now be omitted without changing our above recommendation or delaying the progress of this work.

We have the honour to be, sir,
Your obedient servants,

M. J. BUTLER,
HENRY W. HODGE,
RALPH MODJESKI,
CHARLES MACDONALD.
Chairman, pro. tem.

Hon. GEO. P. GRAHAM, L.L.D., P.C.,
Minister of Railways and Canals,
Ottawa, Ont.

A copy of this report was forwarded to the St. Lawrence Bridge Company, accompanied by a letter from the undersigned, as follows:—

OFFICE OF THE MINISTER OF RAILWAYS AND CANALS,
OTTAWA, February 22, 1911.

The St. Lawrence Bridge Company,
Montreal, Que.

GENTLEMEN,—Hereto annexed you will find a copy of the last report of the Board of Engineers of the Quebec Bridge, signed by Messrs. M. J. Butler, H. W. Hodge, Ralph Modjeski and Charles Macdonald, the two former having been named under the Order in Council to settle differences that had arisen between members of the Board.

Are you prepared to enter into a contract with the government to carry out this undertaking according to this recommendation of the Board? Kindly make it clear that if the government and the Board decide to eliminate the roadways from the bridge, that you are prepared to accept the contract for the construction of the bridge with that modification, under the conditions and at the per pound price named in his report.

As it is part of the conditions that each of the two parent companies holding the stock of the subsidiary company should become parties to the contract, it would be well if these joined in the reply to this communication.

Yours truly,
GEORGE P. GRAHAM.

In reply, the St. Lawrence Bridge Company addressed the following letter to the undersigned:—

ST. LAWRENCE BRIDGE COMPANY, LIMITED,
MONTREAL, QUE., February 23, 1911.

SIR,—We beg to acknowledge receipt of your favour of the 22nd instant, enclosing copy of the last report of the Board of Engineers of the Quebec bridge, dated February 8, 1911, and asking if we are prepared to enter into a contract with the government to carry out this undertaking, according to this recommendation of the Board.

In reply, we beg to say that we are prepared to enter into a contract with the government to carry out this undertaking, according to this recommendation of the Board, and further, should the Government and the Board decide to eliminate the roadways from the bridge, that we are prepared to accept the contract for the construction of the bridge with that modification under the conditions of the

report, and at the per pound price named in our tender for the bridge without roadways reduced four dollars ($4) per ton.

The Dominion Bridge Company, Limited, of Montreal, and the Canadian Bridge Company, Limited, of Walkerville, Ont., the parent companies holding the stock of the St. Lawrence Bridge Company, Limited, are willing to become parties to the contract, and join in signing this letter.

Yours very truly,

ST. LAWRENCE BRIDGE COMPANY, LIMITED,

BY PHELPS JOHNSTON,
President.

We, the undersigned, are prepared to join with the St. Lawrence Bridge Company in the above undertaking.

DOMINION BRIDGE COMPANY, LIMITED,

BY PHELPS JOHNSON,
Vice President.

THE CANADIAN BRIDGE COMPANY, LIMITED,

BY FRANCIS C. MCMATH,
President.

To the Hon. GEORGE P. GRAHAM, LL.D., P.C.,
Minister of Railways and Canals,
Ottawa.

Under date March 14, instant, the Board wrote as follows:—

March 14, 1911.

SIR,—Under date of February 8, your enlarged Board of Engineers recommended the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B' subject to modifications which would, in their opinion, improve the structure and reduce the cost.

In this same report we called your attention to a design of the St. Lawrence Bridge Company omitting the highways, by the adoption of which about $2,600,000 could be saved. This design is marked 'X' and is in every way similar to design 'B' except that it omits the highways but retains two four-foot sidewalks.

We have now been informed by you that the St. Lawrence Bridge Company agree, in view of the modifications mentioned above, to reduce their price on either design by $4 per ton.

We are also informed by you that the Government has decided to omit the highways.

We hand you herewith a diagram (marked Drawing No. 1) showing the design as modified, and we also hand you a memorandum explaining the omissions and revisions required in the specifications, together with a copy of the original printed form with the necessary erasures and additions.

We recommend the signing of a contract for the superstructure of the Quebec Bridge with the St. Lawrence Bridge Company on their design 'X' as modified by attached sketch and under the revised specifications herewith submitted

at a price of (9·02) nine and two-one-hundredths cents per pound, which as given in our report of February 8, will approximately amount to $8,650,000.

We have the honour to be, Sir,
Your obedient servants,
CHARLES MACDONALD,
RALPH MODJESKI,
HENRY W. HODGE.

HON. GEORGE P. GRAHAM,
Minister of Railways and Canals,
Ottawa.

The undersigned, submits the several tenders, and recommends that the design for the superstructure of the railway bridge with two four foot sidewalks as outlined in the report of the Board, dated of March 14, instant, be adopted, and that the tender of the St. Lawrence Bridge Company, Limited, of Montreal, as recommended in this report, at (9·02c.) nine and two-one-hundredths cents per pound, aggregating approximately, $8,650,000, be accepted.

He, further, recommends that the Dominion Bridge Company, Limited, of Montreal, and the Canadian Bridge Company, Limited, of Walkerville, Ont., be made parties to the contract, in such manner as may be deemed advisable by the Department of Justice.

Respectfully submitted,
GEO. P. GRAHAM,
Minister of Railways and Canals.

April 4, 1911.

The undersigned has the honour to recommend that the Order in Council of the 31st of March, ultimo, authorizing entry into contract with the St. Lawrence Bridge Company, Limited, for the superstructure of the Quebec Bridge at the price of 9·02 cents per pound, be supplemented by an authorization for the insertion in the proposed contract of a provision to the effect that, inasmuch as all custom duties upon imported materials are to be paid by the contractors and the contract price of 9·02 cents per pound is based on the tariff of duties at present existing, it is agreed that in case the present tariff be hereafter increased or reduced, the amount of custom duties which, by reason of such increase or reduction, the contractors may pay upon materials imported and entering into the construction of the works over and above or less than the amounts the Contractors would have paid according to the existing rates of duties shall be paid and made good by His Majesty to the Contractors, or by the Contractors to His Majesty, as the case may be.

Respectfully submitted,
(Sgd.) GEO. P. GRAHAM,
Minister of Railways and Canals.

(P.C. 639.)

CERTIFIED *copy of a report of the Committee of the Privy Council, approved by His Excellency the Governor General on the 31st of March, 1911.*

On a memorandum dated 28th of March, 1911, from the Minister of Railways and Canals, submitting the following statement with regard to the steps taken for

the reconstruction of the collapsed Quebec Bridge over the River St. Lawrence, together with a recommendation for the letting of the contract for the superstructure.

It has been thought well, in view of the importance of the subject, and the difficulties that have arisen in dealing with it, that this statement should be a fairly comprehensive one.

The collapse of the bridge occurred on the 29th of August, 1907, while under construction by the Quebec Bridge and Railway Company. In pursuance of the Act of 1908, chapter 59, and an Order in Council, dated the 17th of August, 1908, the whole undertaking, assets, property and franchises of the Quebec Bridge and Railway Company were assumed by the Crown on the 1st of December, 1908, the deed of transfer being dated the 18th of October, 1909.

By an Order in Council of the 17th of August, 1908, a special Board of Engineers was constituted for the purpose of reconstruction of the bridge. The members of the Board were:—Mr. H. E. Vautelet, C.E., M.C.S.C.E., Chairman and Chief Engineer; Mr. Ralph Modjeski, M.I.C.E., M.A.S.C.E., of Chicago, Ill., U.S.A., and Mr. Maurice Fitzmaurice, C.M.G., M.I.C.E., Chief Engineer, of the London County Council, England.

The Board, so constituted, were to make a full examination and prepare a scheme for reconstruction, with a design and specifications, submitting the same to the Department of Railways and Canals for its action thereon. The Board were empowered, in the event of difference of opinion arising, to call in not more than two engineers to advise as to points of difference arising. The entire responsibility for the design and for the work of reconstruction was to rest with the Board.

Suitable offices were obtained and a staff of men, selected by the Board, was, from time to time, appointed, their salaries being approved by Orders in Council.

Under date January 10, 1910, a contract was made with Messrs. M. P. and J. T. Davis, for the piers and abutments of the superstructure. On April 9, 1910, a contract was entered into with Messrs. C. Koenig & Company for the removal of the debris of the old bridge, and on May 11, 1910, a contract was made with the Phœnix Bridge Company for the removal of the approach spans.

Towards the close of the year 1909, the Board had made such progress that on November 24 of that year the Department of Railways and Canals was in a position to invite, by newspaper advertisement, intending bidders, as a preliminary step, to visit the offices of the Board of Engineers in Montreal, where information might be had to enable to prepare tenders. This advertisement, while stating that tenders would be received for a structure on the specifications and according to the design shown on the plans as prepared by the Board, added an invitation to tenderers to submit alternative designs, conforming, however, to the conditions laid down in the Board's specifications.

This admission of alternative designs was the result of a difference of opinion amongst the members of the Board as to the design prepared, and on account of the desire to secure the best possible design; the Board, therefore, considered it advisable that tenders should be called for on the official plan, prepared by their Chairman and Chief Engineer, with the understanding that tenderers should be allowed to present any other design they chose, and that these alternative designs would be fully considered. The Board unanimously adopted a resolution on May 2, 1910, as follows:—

> 'It is resolved that the plans and specifications for a cantilever design now completed be approved and submitted to the Minister for tenders and that in the event of a better plan being submitted by any of the bidders same shall be adopted.'

Tenders were formally called for by the Department of Railways and Canals by newspaper advertisement, dated June 17, 1910. The tenders were to be received up to

September 1, 1910, a date which was subsequently extended, by newspaper advertisement, up to October 1, 1910.

In response, tenders were received from the following parties:—

The Pennsylvania Steel Company, Philadelphia, U.S.A.
Maschinenfabrik Augsburg-Nuremberg, A.G., Gustavsburg, Germany.
The British Empire Bridge Company, Limited, Montreal, and
The St. Lawrence Bridge Company Limited, Montreal.

These tenders were submitted to the Board, the personnel of which had been changed by the retirement of Mr. Fitzmaurice, and the appointment in his stead, by an Order in Council of October 5, 1910, of Mr. Charles Macdonald, M.A.S.C.E., M.I.C.E., the resignation and the appointment to date from September 28, 1910.

Under date October 26, 1910, the Board sent in a report on the tenders received, stating that thirty-five different propositions had been submitted, of which the Board had eliminated, as not acceptable, all but the following:—

1st. Design No. 'V' of the Board, with short shore arms and floating erection of the suspended span on high staging, tenders on which were submitted by all four firms.

2nd. Design 'A' of the St. Lawrence Bridge Company, being different in outline from the Board design and having the top chords built of nickel steel plates throughout.

3rd. Design 'B' of the St. Lawrence Bridge Company, similar in all respects to design 'A,' except that the top chords of the anchor arms are built of carbon steel.

4th. Design 'C' of the St. Lawrence Bridge Company, similar in all respects to 'B,' with the exception of the top chords, which are designed with eyebars, instead of plates.

The Board observe that, classified for cost, these are as follows:—

1.	British Empire Bridge Co., Board's design V.	$11,025,566
2.	Pennsylvania Steel Co., Board's design V.	11,686,751
3.	St. Lawrence Bridge Co., design 'B'.	11,957,500
4.	" " " 'A'.	12,153,500
5.	" " " 'C'.	12,216,400
6.	Maschinenfabrik Augsburg, Board's design V. . .	13,230,050
7.	St. Lawrence Bridge Co., Board's design V.	14,867,170

They add that the cost, as per specifications, may be increased by 2 per cent, and includes an amount of $118,500 to be paid for increased quantities of masonry in the anchor and short piers. They express the opinion that it is possible to construct a bridge in accordance with either of the tenders received upon the Board's design No. V, which would make a satisfactory structure; also, that it is possible to construct a bridge in accordance with the designs 'A,' 'B' and 'C' submitted by the St. Lawrence Bridge Company, which would make a satisfactory structure, providing that plans, details and material were made in accordance with the specifications of the Board, including modifications allowed to other bidders.

This report was signed by all three members of the Board.

In view of the fact that no definite recommendation was made in this report as to the acceptance of any individual tender, the Minister wrote the Board on November 1, 1910, and asked that they make a recommendation as to what tender, under all the circumstances, should be accepted.

To this a reply was received from two members of the Board, Messrs. Macdonald and Modjeski, under date of November 3. They state that on close investigation of the alternative designs it was found that one, presented by the St. Lawrence Bridge Company, while designed on the single intersection principle, in a very practical way met all the demands that a portion of the Board had in their minds when

they favoured the double intersection principle. They observe further that a bridge could undoubtedly be constructed on the official design, and once erected would be a substantial structure; but that they are of the opinion that design 'B' of the St. Lawrence Bridge Company, in addition to providing for a satisfactory bridge offers features which simplify the erection and minimize the risk to both life and property entailed in a work of such magnitude, which they consider of paramount importance. For this, and other reasons, they recommend the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B'.

This report not having been signed by Mr. Vautelet, on communication with him, he wrote the Minister, on December 10, 1910, dealing with the several grounds taken by his colleagues in recommending the acceptance of design 'B' of the St. Lawrence Bridge Company, stating that neither it, nor the other designs by the Company, comply with the requirements that the Board have expressed in the specifications, and should not, therefore, be considered. He adds that the Board's design complies with all the requirements, both of the Board and of the Department, and that he knows no technical reason why either of the four tenders on this design should not be accepted. He states that he could not join in the recommendation of his colleagues for the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B'.

Under these circumstances, it being clear that a serious difference had arisen, Messrs. M. J. Butler, C.M.G., M.C.S.C.E., and Henry W. Hodge, M.A.S.C.E., M.I.C.E., were called in to advise the Board in the matter, and under date the 8th of February, 1911, a report was sent in by the Board, signed by Mr. Macdonald, Chairman *pro tem.*, in the absence of Mr. Vautelet, who was absent through illness, Mr. Modjeski, Mr. Hodge, and Mr. Butler. This report is as follows:—

BOARD OF ENGINEERS, QUEBEC BRIDGE.
MONTREAL, February 8, 1911.

Hon. GEO. P. GRAHAM, LL.D., P.C.,
Minister of Railways and Canals,
Ottawa, Ont.

SIR,—In accordance with your letter of January 30, appointing Messrs. M. J. Butler and Henry W. Hodge to advise with the Board of Engineers, Quebec Bridge, on the points of difference that have arisen in that Board, we have the honour to report as follows:—

The Board, with the exception of Mr. Vautelet, who is detained in his home by illness, met with the advisory engineers on February 6, and have been in session for the past three days, Mr. Macdonald acting as temporary Chairman.

We have examined the various tenders and general designs and the advisory engineers have read the written opinions of the members of the Board, and in addition thereto, the opinion of Mr. Vautelet, as expressed in his letter to them dated February 2. They have also considered the verbal arguments of each member of the Board, adjourning to Mr. Vautelet's residence for the purpose of conferring with him.

The only point of difference in the Board is as to which specific design and tender should be recommended for acceptance; the Board being divided between the official design and the design of the St. Lawrence Bridge Company.

None of the tenders on either of these two designs were made without requiring modifications of the specifications, so that such alterations must be considered if any of these tenders are to be accepted.

The advisory engineers have not considered it within the province of their appointment to examine closely into the details of the two above mentioned

designs, and all of us are of the opinion that consideration of details is a matter that must be carefully studied and worked out in the light of further tests yet to be made by the Board of Engineers.

From our examination of the two above mentioned general designs, we, the undersigned, agree that the design of the St. Lawrence Bridge Company is preferable for the following reasons:

(*a*) The type of design offers greater safety to life and property during erection, as well as economy and rapidity in construction.

(*b*) The design contains the minimum number of secondary members and requires few, if any, temporary members during erection.

(*c*) The system of triangulation by dividing the web stresses reduces the members to more practical sections and simplifies the details of connections.

(*d*) The design economizes material as shown by the calculated weights of the two designs.

(*e*) The general appearance of the structure is, in our opinion, improved.

We feel that in a work of such magnitude the question of design is of the first importance, and for the reasons given above we recommend the acceptance of design 'B' of the St. Lawrence Bridge Company, subject to certain modifications in general outline and detail, which we deem advisable and which will result in economy, and further improvement in appearance. The modifications of their design we have in mind will reduce the cost of the work by, at least, four dollars per ton and we recommend the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B' at a price not exceeding 8·45 cents per pound (amounting in the calculated weight to $11,246,100) and at a corresponding reduction on their other pound prices, if the Board should decide to accept any features of their alternative tenders.

The lowest tender of the British Empire Bridge Company, when the additional price they give for complying with the splices required by the official design is added, amounts to $11,320,720.

While not called for by the advertisement, the St. Lawrence Bridge Company submitted, among their tenders one omitting the roadways, which at the reduction in their pound price above mentioned, shows a cost of $8,650,000 on the figured weight and we think this should be called to your attention, as the highway can now be omitted without changing our above recommendation or delaying the progress of this work.

We have the honour to be, sir,

Your obedient servants,

M. J. BUTLER,

HENRY HODGE,

RALPH MODJESKI,

CHARLES MACDONALD,

Chairman, pro. tem.

A copy of this report was forwarded to the St. Lawrence Bridge Company, accompanied by a letter from the Minister of Railways and Canals, as follows:—

OFFICE OF THE MINISTER OF RAILWAYS AND CANALS,
OTTAWA, February 22, 1911.

The St. Lawrence Bridge Company,
Montreal, Que.

GENTLEMEN,—Hereto annexed you will find a copy of the last report of the Board of Engineers of the Quebec Bridge, signed by Messrs. M. J. Butler, H. W. Hodge, Ralph Modjeski and Charles Macdonald, the two former having been named under the Order in Council to settle differences that had arisen between members of the Board.

Are you prepared to enter into a contract with the Government to carry out this undertaking according to this recommendation of the Board? Kindly make it clear that if the Government and the Board decide to eliminate the roadways from the bridge, that you are prepared to accept the contract for the construction of the bridge with that modification, under the conditions and at the per pound price named in this report.

As it is part of the condition that each of the two parent companies holding the stock of the subsidiary company should become parties to the contract, it would be well if these joined in the reply to this communication.

Yours truly,

GEO. P. GRAHAM.

In reply the St. Lawrence Bridge Company addressed the following letter to the Minister of Railways and Canals,—

ST. LAWRENCE BRIDGE COMPANY, LIMITED,
MONTREAL, QUE., February 23, 1911.

To the Honourable
GEORGE P. GRAHAM, LL.D., P.C.,
Minister of Railways and Canals,
Ottawa.

SIR,—We beg to acknowledge receipt of your favour of the 22nd instant, enclosing copy of the last report of the Board of Engineers of the Quebec Bridge, dated February 8, 1911, and asking if we are prepared to enter into a contract with the Government to carry out this undertaking, according to this recommendation of the Board.

In reply, we beg to say that we are prepared to enter into a contract with the Government to carry out this undertaking, according to this recommendation of the Board and further, should the Government and the Board decide to eliminate the roadways from the bridge, that we are prepared to accept the contract for the construction of the bridge with that modification under the conditions of the report, and at the per pound price named in our tender for the bridge without roadways reduced four dollars ($4) per ton.

The Dominion Bridge Company, Limited, of Montreal, and the Canadian Bridge Company, Limited, of Walkerville, Ont., the parent companies holding the

stock of the St. Lawrence Bridge Company, Limited, are willing to become parties to the contract, and join in signing this letter.

Yours very truly,

ST. LAWRENCE BRIDGE COMPANY, LIMITED,
BY PHELPS JOHNSON,
President.

We, the undersigned, are prepared to join with the St. Lawrence Bridge Company in the above undertaking.

DOMINION BRIDGE COMPANY LIMITED,
BY PHELPS JOHNSON,
Vice-President.

THE CANADIAN BRIDGE COMPANY, LIMITED,
BY FRANCIS C. MCMATH,
President.

Under date March 14, 1911, the Board wrote as follows:—

March 14, 1911.

HON. GEORGE P. GRAHAM,
Minister of Railways and Canals,
Ottawa.

SIR,—Under date of February 8, your enlarged Board of Engineers recommended the acceptance of the tender of the St. Lawrence Bridge Company on their design 'B' subject to modifications which would, in their opinion, improve the structure and reduce the cost.

In this same report we called your attention to a design of the St. Lawrence Bridge Company omitting the highways, by the adoption of which about $2,600,000 could be saved. This design is marked 'x' and is in every way similar to design 'B' except that it omits the highways but retains two four-foot sidewalks.

We have now been informed by you that the St. Lawrence Bridge Company agree, in view of the modifications mentioned above, to reduce their price on either design by $4 per ton.

We are also informed by you that the Government has decided to omit the highways.

We hand you herewith a diagram (marked Drawing No. 1) showing the design as modified, and we also hand you a memorandum explaining the omissions and revisions required in the specifications, together with a copy of the original printed form with the necessary erasures and additions.

We recommend the signing of a contract for the superstructure of the Quebec Bridge with the St. Lawrence Bridge Company on their design 'X' as modified by attached sketch and under the revised specifications herewith submitted at price of (9·02) nine and two-one-hundreths cents per pound, which as given in our report of February 8, will approximately amount to $8,650,000.

We have the honour to be, Sir,

Your obedient servants,

CHARLES MACDONALD,
RALPH MODJESKI,
HENRY W. HODGE.

The Minister submits the several tenders and recommends that the design for the superstructure of the railway bridge, with two four-foot sidewalks, as outlined in the report of the Board, dated the 14th of March, 1911, be adopted, and that the tender of the St. Lawrence Bridge Company, Limited, of Montreal, as recommended in this report, at (9·02c.) nine and two-one-hundredths cents per pounds, aggregating, approximately, $8,650,000 be accepted.

The Minister further recommends that the Dominion Bridge Company, Limited, of Montreal, and the Canadian Bridge Company, Limited, of Walkerville, Ont., be made parties to the contract, in such manner as may be deemed advisable by the Department of Justice.

The Committee submit the same for approval.

RODOLPHE BOUDREAU,
Clerk of the Privy Council.

The Honourable,
THE MINISTER OF RAILWAYS AND CANALS.

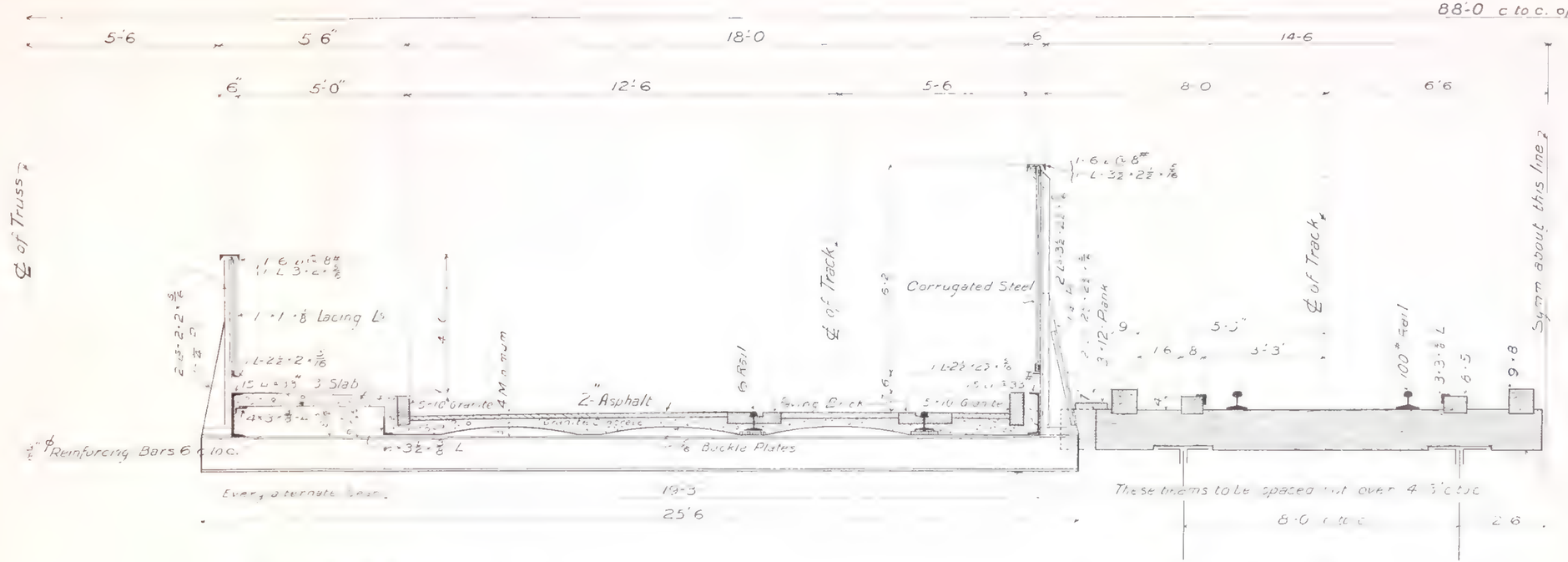
(P.C. 715.)

CERTIFIED *copy of a Report of the Committee of the Privy Council, approved by His Excellency the Governor General on the 5th April 1911.*

The Committee of the Privy Council, on the recommendation of the Minister of Railways and Canals, advise that the Order in Council of the 31st of March, 1911, authorizing entry into contract with the St. Lawrence Bridge Company, Limited, for the superstructure of the Quebec Bridge at the price of 9·02 cents per pound, be supplemented by an authorization for the insertion in the proposed contract of a provision to the effect that, inasmuch as all custom duties upon imported materials are to be paid by the Contractors and the contract price of 9·02 cents per pound is based on the tariff of duties at present existing, it is agreed that in case the present tariff be hereafter increased or reduced, the amount of custom duties which, by reason of such increase or reduction, the Contractors may pay upon materials imported and entering into the construction of the works over and above or less than the amounts the Contractors would have paid according to the existing rates of duties shall be paid and made good by His Majesty to the Contractors, or by the Contractors to His Majesty, as the case may be.

RODOLPHE BOUDREAU,
Clerk of the Privy Council.

THE HONOURABLE,
The Minister of Railways and Canals.



Weight of all material above cross beams
= 2970 lbs per lineal foot for each Roadway

Weight of all material above stringers
= 670 lbs per lineal foot per track

8"×12" Ties - 13'-0 lg Sized to 11½"-12" c to c
Every 4th Tie to be 14'-0 lg

BOARD OF ENGINEERS
QUEBEC BRIDGE

CROSS SECTION OF FLOOR

SCALE - ⅜" = 1'-0"

Made by - L.J.L. - Date - Nov 30-09

Traced by - L.J.L. - Date - Nov 30-09

Checked by G.F.P. Date - [illegible]

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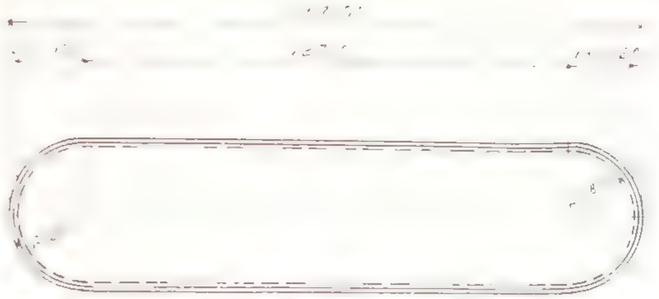
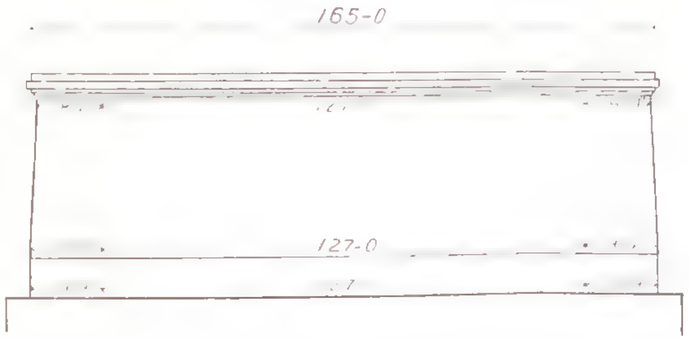
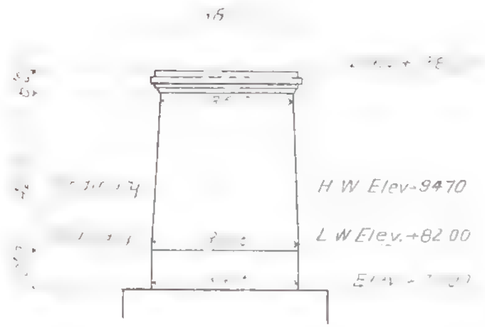


PLAN



SIDE ELEVATION



END ELEVATION

QUEBEC BRIDGE

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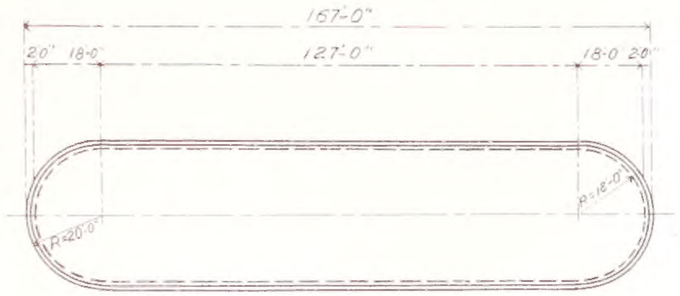

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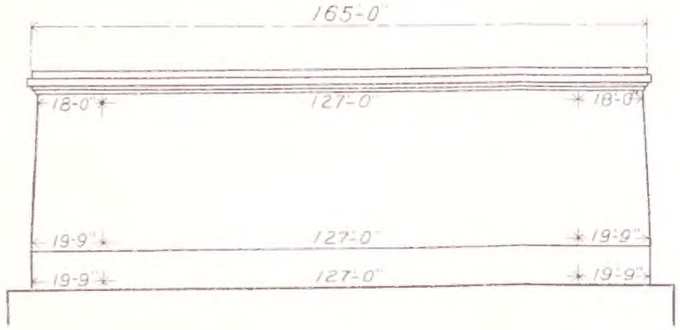
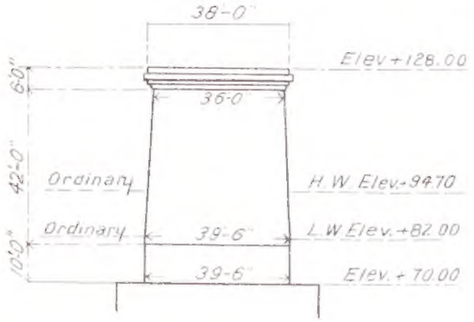


SIDE ELEVATION

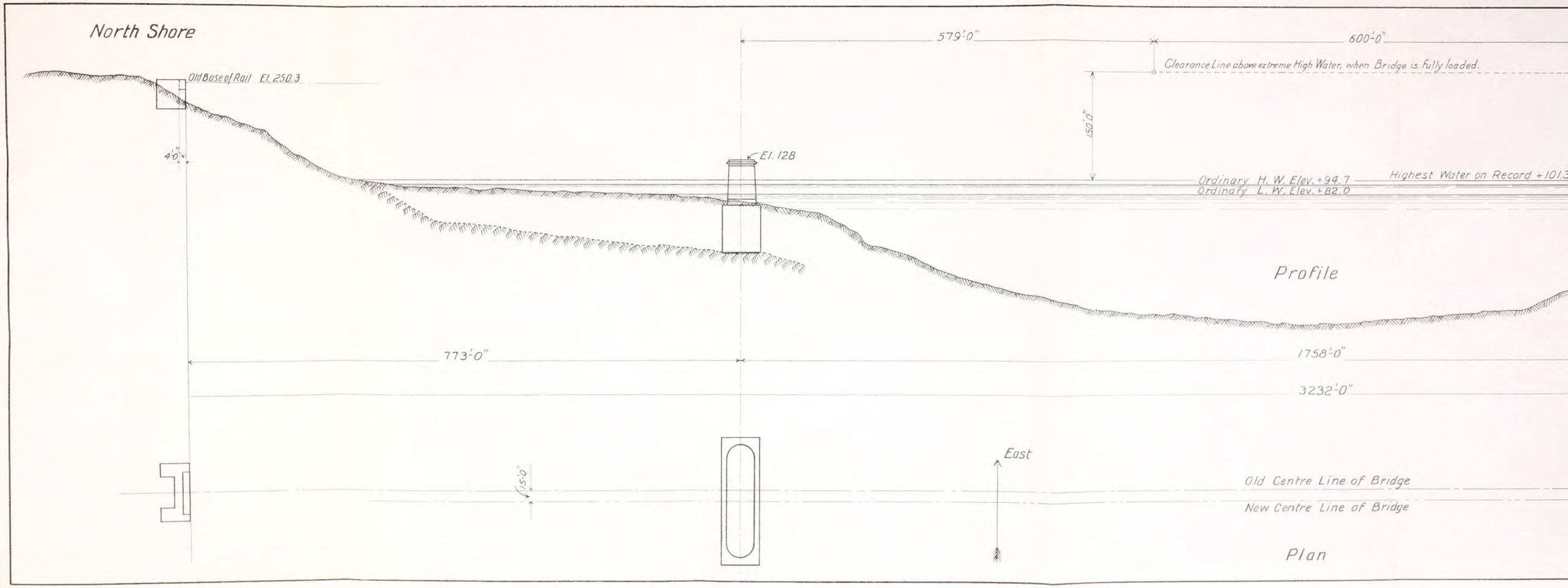


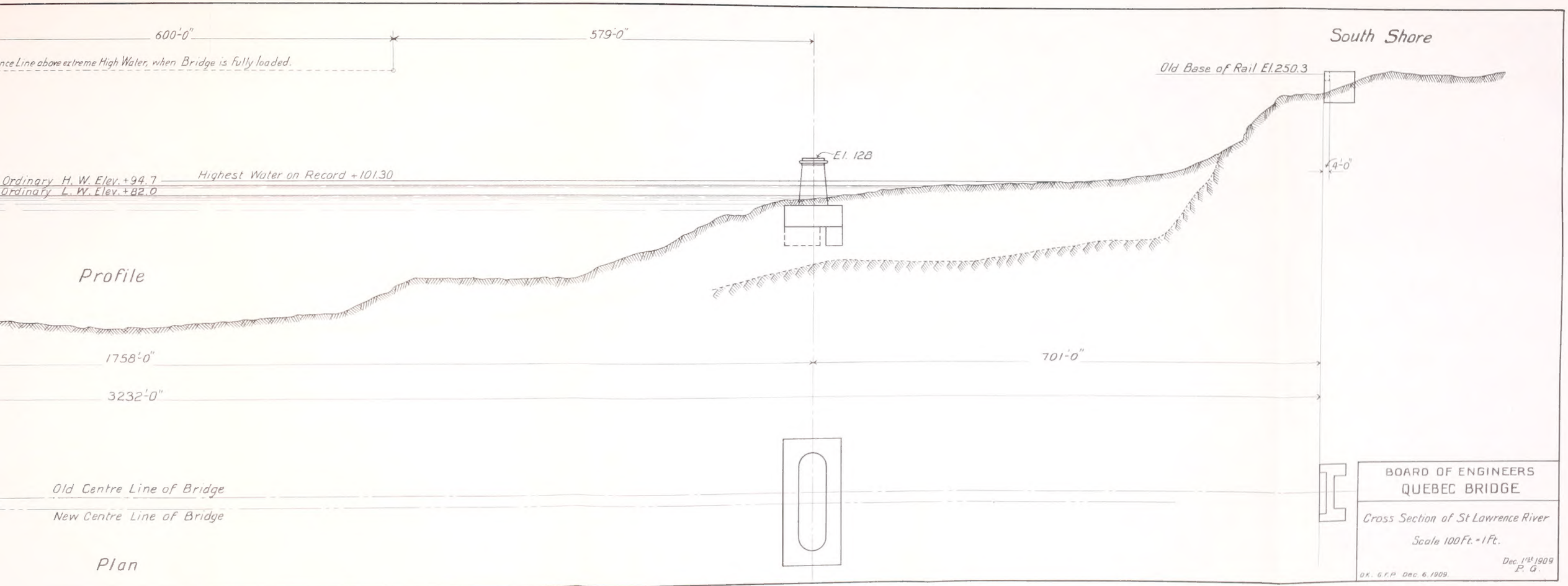
END ELEVATION

BOARD OF ENGINEERS
QUEBEC BRIDGE

MAIN PIERS
FOR 1758-FOOT SPAN

Scale 1 inch = 40 ft.
Made by J.A.B. Nov 30-1909
O.K. G.F.P. Dec 6 1909


North Shore
579'-0"
600'-0"
Clearance Line above extreme High Water, when Bridge is fully loaded.
Old Base of Rail El. 250.3
150'0"
4'-0"
El. 128
Ordinary H. W. Elev. +94.7
Highest Water on Record +101.3
Ordinary L. W. Elev. +82.0
Profile
773'-0"
1758'-0"
3232'-0"
15'-0"
East
Old Centre Line of Bridge
New Centre Line of Bridge
Plan


600'-0"
579'-0"
nce Line above extreme High Water, when Bridge is fully loaded.
South Shore
Old Base of Rail El. 250.3
El. 128
4'-0"
Ordinary H. W. Elev. +94.7
Ordinary L. W. Elev. +82.0
Highest Water on Record +101.30
Profile
1758'-0"
701'-0"
3232'-0"
Old Centre Line of Bridge
New Centre Line of Bridge
Plan
BOARD OF ENGINEERS
QUEBEC BRIDGE
Cross Section of St Lawrence River
Scale 100 Ft. = 1 Ft.
Dec. 1st 1909
P. G.
O.K. G.F.P. Dec. 6, 1909.

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